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TECHNICAL MEMORANDUM

Date: October 2011 **Project No.:** 073-8611410

To: United States Environmental Protection Agency (USEPA)

From: Golder Associates Inc.

cc: *de maximis*

RE: **ARSENIC NATURAL ATTENUATION EVALUATION AT THE MARTIN AARON SUPERFUND SITE IN CAMDEN, NEW JERSEY**

1.0 INTRODUCTION

The purpose of this Technical Memorandum is to provide the United States Environmental Protection Agency (USEPA) with the results of an extensive investigation to evaluate the natural attenuation capacity of the Meadow Mat Complex[1] (MMC) which exists as part of the hydrogeologic system located on the Martin Aaron Superfund Site (Site). The natural attenuation capacity of the MMC was evaluated through the performance of a comprehensive stratification, geochemical and arsenic stability study. The results of that study establish that the MMC will provide an effective, stable, long term reactive and hydraulic barrier preventing potentially leachable arsenic and other inorganic compounds ,located at and in the area of the Site, from reaching the Upper-Potomac-Raritan-Magothy (UPRM) aquifer both during and after implementation of Remedial Action. Specifically, this Technical Memorandum demonstrates that removal of the primary source[2] of arsenic impacts to groundwater (i.e., removal of the White Material) and the preservation of the MMC to maintain the favorable natural attenuation processes during and after Remedial Action, will achieve the Site Remedial Action Objectives of the Record of Decision (ROD) and will provide a more effective and protective remedy without unnecessarily burdening and/or disrupting the community. The RAOs are as follows:

- Reduce or eliminate the direct contact threat associated with contaminated soil to levels protective of a commercial or industrial use and protective of the environment
- Prevent erosion and off-site transport of contaminated soils
- Reduce or eliminate the migration of Site contaminants from soil to groundwater and surface waters
- Prevent public exposure to contaminated groundwater that presents a significant risk to human health and the environment
- Minimize or eliminate organic vapor migration from groundwater into future indoor environments that may be built on the Site

[1] A stratigraphic unit composed of glauconitic clays/silts and peat that represents the surface of former tidal marshes that were present prior to development of this area of Camden in the mid- to late- 1800s. More information is provided in Section 3.1.

[2] USEPA. 1999. *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*, EPA/OSWER No. 9200.4-17P, Office of Solid Waste and Emergency Response, Washington DC. states that "Control of source materials is the most effective means of ensuring the timely attainment of remediation objectives"

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The overall objective of the MMC evaluation program is to identify the processes controlling arsenic sequestration onto MMC mineral phases, demonstrate the capacity of these mineral phases, and evaluate the long-term stability of solid-phase arsenic as a function of existing and anticipated future groundwater chemistry[3] and Site redevelopment. The findings of this study clearly demonstrate that arsenic is sequestered within the solid-phase in the upper-most portion of the MMC-Clay[4] with a strongly declining concentration gradient as a function of depth. The Cape May Formation sands below the MMC are not impacted. Based on the Site geochemistry and MMC solid-phase characterization, the most likely association of arsenic in the MMC-Clay is with naturally occurring iron-bearing mineral phases. Because Site arsenic impacts have existed for more than 100 years and conditions have remained stable (i.e., arsenic has remained sequestered in the uppermost portion of the MMC-Clay), the presence and sequestration capacity of the MMC is adequate and will be stable in the long term. Thus, the MMC unit should be left intact.

[3] As defined in the USEPA. 2007. *Monitored Natural Attenuation of Inorganic Contaminants in Groundwater*, Volumes 1 and 2.
[4] MMC-Clay refers to the glauconitic clays/silts that make up the top portion of the MMC unit.

2.0 BACKGROUND

The Conceptual Site Model (CSM) for the Site presented by USEPA in the 2004 Remedial Investigation/Feasibility Study Report included a conclusion that areas of historic fill material at the Site contain arsenic at concentrations greater than background (300 parts per million [300 ppm]) as a result of prior Site activities, and that these areas represent potential sources of groundwater quality impact that need to be removed. Accordingly, the remedy selected by USEPA in the ROD includes (among other things), the excavation and off-site disposal of these areas of Historic Fill.

An extensive Pre-Design Investigation (PDI) Program to complete the delineation of the areas of Historic Fill and to update and improve upon the CSM for the Site has been undertaken. Although the PDI work has confirmed many of the 2004 RI conclusions, significant modifications to the CSM relative to arsenic contamination in the subsurface have evolved. This updated CSM includes the presence of a distinct arsenic source area (White Material), the widespread presence of the MMC, and the concept that arsenic is being naturally attenuated[5] by the MMC. Furthermore, the subsurface conditions identified during the PDI establishes that the MMC should be preserved to provide a long-term hydraulic and geochemical barrier against the future transport of inorganic contaminants in shallow perched groundwater into the UPRM aquifer.

The most compelling evidence to support preservation of the MMC, prior to the arsenic natural attenuation program, was a documented decrease in arsenic concentration in groundwater from above the MMC to below the MMC and elevated solid-phase arsenic concentrations within the clay unit of the MMC observed during the 2009 PDI. Based on these observations, the arsenic natural attenuation program described in this Technical Memorandum was developed and completed to evaluate specific influences of the MMC on arsenic mobility and long-term stability.

The following provides a timeline of activities at the Site which details the investigatory work and major Agency communications that have occurred since the 2009 PDI.

- **Summer 2009 – Completion of Stage 1 PDI Activities**
  - The overall findings of the Stage I PDI Activities include the following:
    - Broad layer of “White Material” observed above the MMC represents the primary source of arsenic to groundwater
    - Historic Fill contains arsenic at concentrations less than 300 ppm
    - Contrary to what was reported in the post-ROD Soil Investigation of the Ponte Equities Site Report[6], no “Tannery Waste/Sludge” was observed during the PDI

[5] The term natural attenuation has been defined by the Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-17P as the reliance on natural attenuation processes to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods. In the context of a site remedy, monitored natural attenuation (MNA) can provide an effective knowledge-based remedy where a thorough engineering analysis informs the understanding, monitoring, predicting, and documenting of the natural processes.
[6] Lockheed Martin. 2006. *Soil Investigation of the Ponte Equities Site*, WA #0-183, Final Trip Report

- MMC is an effective geochemical barrier that limits the transport of arsenic in groundwater, and therefore, should not be disturbed
- Based on groundwater collected from the perched water monitoring well MW-01S and its corresponding UPRM monitoring well MW-01M, a significant contrast in arsenic groundwater concentration was observed, 26,100 ug/L versus 15.8 ug/L, respectively. This supports the finding that the MMC acts locally to stabilize arsenic in the solid-phase.
- 13 of 14 S-Series monitoring wells were confirmed or were suspected of being screened across, or within the MMC, and as a result, represented a hydraulic conduit for the transport of water from above the MMC to the UPRM.

- **October 2009 – USEPA Meeting**
  - Meeting was held to present the PDI Stage I results, to present unique Site conditions which differed from those reported in the Remedial Investigation and Feasibility Study (RI/FS) and the ROD, and to propose preservation of the MMC as an important natural attenuation feature of the Site
  - USEPA recommended that additional investigative work was needed to document the character, and stabilization, of arsenic within the MMC to support preservation of the MMC
- **November 2009 Technical Memorandum**
  - In response to USEPA, the November 2009 Technical Memorandum proposed abandonment of 14 S-series monitoring wells (screened above, within, and/or through the MMC) to eliminate communication between perched shallow groundwater (in contact with White Material) and the UPRM aquifer and construction of 7 SM-series wells screened entirely below the MMC to provide a more accurate representation of groundwater impacts and the protectiveness of the MMC
  - Approved by USEPA on March 29, 2009
- **December 2009 Technical Memorandum**
  - Procedure for evaluating the stratification of arsenic within the MMC (Stratification Program)**.** The purpose of the program was to collect arsenic concentration data at high vertical resolution (6-inch intervals) within the MMC to evaluate vertical stratification of arsenic across the MMC. USEPA indicated during the October 21, 2009 meeting that this information was necessary to support the concept that the MMC should remain in place
  - Approved by USEPA on April 7, 2010
- **May 2010 Addendum No. 1 to December 2009 Technical Memorandum**
  - Additional procedure for evaluating the oxidation-reduction conditions (redox conditions) within the MMC (Geochemistry Program). The purpose of the program was for additional sampling and analytical testing to complete the geochemistry evaluation of the MMC including methods to collect samples under anoxic preservation
  - Approved by USEPA on June 7, 2010
- **August 2010 Addendum No. 2 to December 2009 Technical Memorandum**
  - Additional procedure for evaluating the stability of solid-phase arsenic in the MMC (Stability Program). The purpose of the program was to complete analytical testing on the MMC samples, collected under anoxic preservation, using a sequential extraction procedure (SEP) to evaluate arsenic partitioning in the solid phase
  - Approved by USEPA on October 7, 2010

- **August 2010 to March 2011 Implementation of the Field and Laboratory Program**
  - Completed field activities with USEPA oversight in August 2010
  - Completed laboratory analysis of samples in March 2011
- **July 18, 2011 meeting with USEPA**
  - Presented results of the groundwater monitoring, Stratification, Geochemistry, and Stability programs
  - USEPA recommended that the Group submit a report presenting the results of this investigation

This TM provides an update to the CSM and the arsenic natural attenuation evaluation based on site-specific data collected from the investigations described above.

3.0 UPDATED CONCEPTUAL SITE MODEL

3.1 Summary of Site History and Geologic Setting

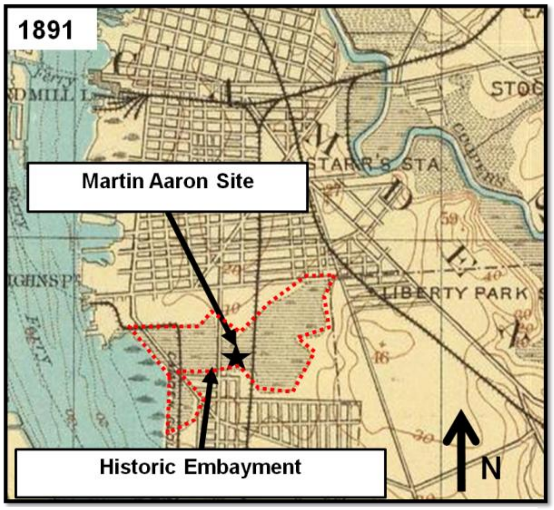


Figure 1 – Historic Map of Camden (circa 1891)

The Site has been used for industrial activities since at least 1886, including the operation of a tannery from approximately 1886 through 1940. Historical topographic maps (e.g., U.S. Geological Survey) show that prior to, and during, industrial development, a large portion of this area of Camden was drained by a tidal embayment that opened into the Delaware River (Figure 1). During the latter part of the 1800s and into the early 1900s, many of these tidal embayments were filled with assorted materials, including dredge materials from the Delaware River to build land for industrial/commercial expansion.

As such, and as documented by USEPA, the Site is underlain by Historic Fill placed above the former natural estuarine deposits (MMC), which occurred prior to land development and continued to occur through the historic use of the Site. The MMC is a widely recognized geologic unit in New Jersey known to have formed when the area of the Site was a tidal embayment to the Delaware River. It is a common feature at sites in the coastal plain with similar hydrogeological histories. Meadow Mat/Estuarine Marsh materials are defined by highly organic layers consisting of reeds, roots, and wood matter interbedded with a glauconitic silty clay and clayey horizon. From a depositional standpoint, the reeds, roots, and wood matter represent the former foliage present in a cedar-type wetland environment that would be tidally inundated with water. This estuarine unit would trap fine-grained materials in the root and vegetation mass creating the glauconitic silty clay and clayey horizon that sits above the present-day peat material. At the Site the MMC is typically from 1 to 2 feet thick, but up to 4 feet thick in the western portion of the Site near Broadway. The MMC generally occurs at elevations from approximately 8 feet below ground surface (bgs) to approximately 10 feet bgs.

The geologic units on-Site from youngest to oldest identified as being related to surficial and near surface materials, are as follows:

- Historic Fill[7]
- Meadow Mat Complex
- Cape May Formation[8]

[7] Mixed fill material that has been used as the land surface following Site development. Recent C&D debris (approximately 1 to 2 feet) overlies the mixed fill material on Site except for the southern and southeastern portions of the Site beneath the contiguous Ponte Equities Property one-story and three-story buildings.

- Semi-Confining Clay
- Magothy Formation[9]

The overall stratigraphy of the Site is shown in a series of cross-sections provided in Attachment 1. Also, isopach thickness maps illustrating the presence and thickness of the MMC-Clay and White Material are included in Attachment 1.

3.2 Summary of Primary Arsenic Source

A discrete and generally continuous layer of “White Material” observed across a portion of the Site has been identified as the primary source of arsenic in soil and groundwater. The presence of White Material has been observed, and visually delineated, in a relatively continuous layer across a significant portion of the Site as shown in the isopach thickness map included in Attachment 1.

Figure 2 Photograph of White Material in a test pit at the Martin Aaron Site. Inset is a photograph of a preserved newspaper dated 1909 directly at the White Material MMC contact.

Overall, the arsenic chemistry in the White Material can be summarized as follows:

- Contains arsenic concentrations up to 19,800 mg/kg
- Contains an average concentration (geometric mean) of arsenic of 1,734 mg/kg based on 29 samples
- Represents the primary source of arsenic impacts to groundwater
- Depleted in arsenic concentration in some areas due to mobilization and transport of arsenic into the underlying MMC-Clay

The White Material exists stratigraphically directly above the MMC-Clay unit and varies in thickness from 0.5 to 2 feet. A marker (newspaper) was found in a test pit on-Site and places the White Material disposal as early as 1909 directly at the MMC contact (Figure 2).

[8] Fine-to-coarse sand, minor silt and clay; yellow, brownish-yellow, reddish-yellow, very pale brown, light-gray; minor pebble gravel. Well stratified quartz sand, with shells and a little glauconite. As much as 10 feet thick in Site area. Deposited in freshwater embayments along ancestral Delaware River covered by subsequent deposition of MMC.

[9] Quartz sand, fine to very coarse-grained, and clay and silt, thin-bedded. Sand is white, yellow, light-gray; clay and silt are white, yellow, brown, reddish-yellow and gray to black. Sand includes some lignite, pyrite, and minor feldspar and mica (in deepest Site boreholes) well defined geologic unit that extends across region.

After the White Material was recognized to be the significant source material across the Site during the 2009 PDI[10] (see Figure 3 for interpreted extent[11]), research was performed to better determine the origins of this material. The presence and description of White Material at the Site is consistent with the United Kingdom Department of the Environment (DOE) Industry Profile of Animal and Animal Products Processing Works, which describes a white sludge material that is/was commonly generated at tannery facilities. As noted in this report, “the specific composition of the sludge produced is dependent on specific tanneries activities, but likely contains water, lime, arsenic (III) oxide salts, hydrated chromium (III) oxide salts, residual sulfides, and organic matter (hide and hair proteins, fats, oils, and dye stuffs)”. The White Material observed at the Site is entirely consistent with the physical description provided above.

Figure 3 Interpreted extent of White Material

3.3 Arsenic Distribution in Soil

3.3.1 Historic Fill

Overall, the arsenic chemistry within the Historic Fill can be summarized as follows:

- Historic Fill contains an average concentration (geometric mean) of arsenic of 67 mg/kg based on 80 samples
- Individual samples with arsenic concentration greater than 300 mg/kg were observed at 6 locations in Historic Fill during the 2009 PDI
  - Arsenic concentration in these samples range from 325 mg/kg to 975 mg/kg
  - Several of these samples are likely associated with some White Material or MMC-Clay and are located in areas where post-tannery construction occurred and disturbed the stratigraphy
- 7 Post-ROD Ponte Equities boring samples exceed 300 mg/kg in Historic Fill

[10] It is important to note that during the New Jersey Department of Environmental Protection (NJDEP) Remedial Investigation a test pit was excavated (TP-21) in the northeastern portion of the Site and the geologist recorded the presence of a “white powdery substance with blue to yellow/blue tint”. This is the only observation, prior to the 2009 PDI, of a white powdery substance in any of the Site investigations performed (Kimball Associates, 2000, Draft Remedial Investigation Report).

[11] The interpreted extent of White Material assumes that the eastern section of the Site along Sixth Street likely contained White Material although visual delineation was not comprehensive. The Rhodes Drum building and Ponte One-Story building foundations are located in this area and the White Material was observed to significantly decrease in thickness potentially due to compression from the weight of these structures. In addition, several USEPA removal actions occurred in this area, along with the presence of a utility corridor, and the presence of a historic railroad spur, all of which could have disturbed the White Material. White Material in this area will be further delineated (visually) during the Stage II PDI.

- The highest concentration of arsenic in Historic Fill is located beneath the former one-story Ponte Equities Building (20,300 mg/kg)
  - Results are inconsistent with data from the rest of the Site which presents the White Material as the primary source of arsenic to groundwater and does not show significant impacts from arsenic in the overlying Historic Fill.
  - The datum used to establish depth of collected samples below ground surface is in question and it is uncertain if these samples were collected in Historic Fill or other material
  - Surrounding 2009 PDI boring samples collected from Historic Fill in this area observed arsenic concentrations less than 300 mg/kg
  - Elevated arsenic concentrations in Historic Fill appear to be at discrete locations and depths

3.3.2 Meadow Mat Complex

Overall, the arsenic chemistry in the MMC can be summarized as follows:

- Contains an average concentration (geometric mean) of arsenic of 329 mg/kg based on 118 samples
- Arsenic concentrations are more elevated in the upper portion of clay/silt layer
- Samples with the highest arsenic concentrations are either directly below or adjacent to the White Material area of extent
- The MMC-Peat generally has arsenic concentrations less than 300 mg/kg
  - Two samples collected in the MMC-Peat contain arsenic concentrations greater than 300 mg/kg at 903 mg/kg and 371 m/kg

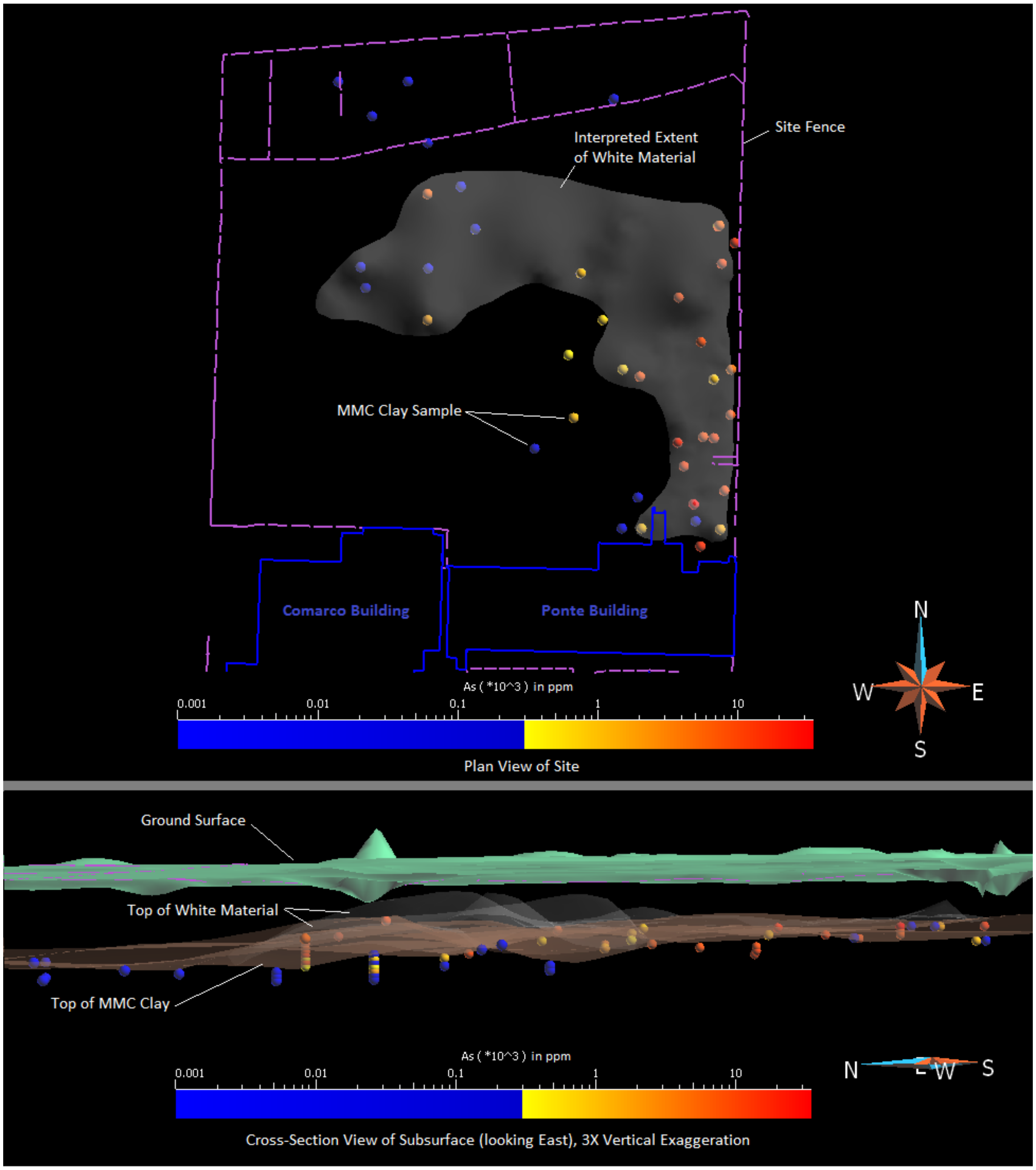


Figure 4 Plan view and cross-section view of arsenic impacts in the MMC

Figure 4 illustrates the plan view and cross-section view of arsenic impacts in the MMC. The most impacted portions of the MMC are either below, or directly adjacent to, the currently known (from visual delineation) and interpreted extent of White Material. In particular, the most significant concentrations of arsenic are observed in the eastern portion of the Site along the Site boundary with 6th Street.

3.3.3 Cape May Formation (Sand)

Overall, the arsenic chemistry in the Cape May Formation sand can be summarized as follows:

- Contains an average concentration (geometric mean) of arsenic of 10 mg/kg based on 17 samples (approximately equal to natural background as per NJDEP cleanup standards)
- No samples collected in the Cape May Formation contain arsenic concentrations greater than 300 mg/kg

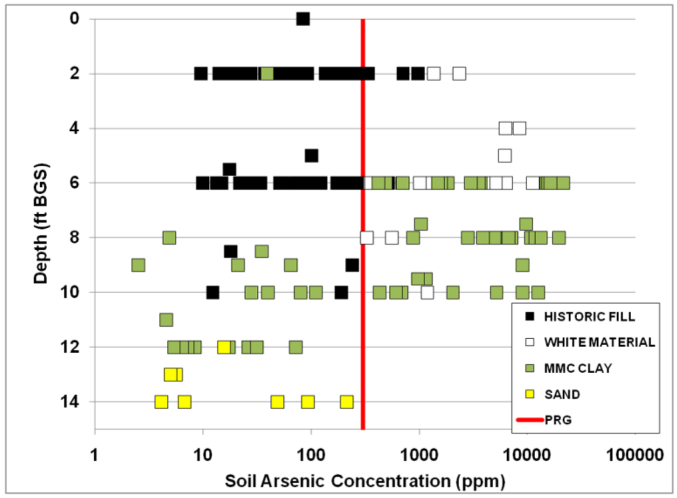


Figure 5 Overall distribution of arsenic in soil

The overall distribution of arsenic, as a function of depth, in the source material and in each of the recognized geologic units is presented in Figure 5. In addition to the source material (White Material), the only unit that contains average arsenic concentrations greater than 300 mg/kg is the MMC-Clay. As demonstrated by the high-resolution sampling, there is an abrupt decrease in arsenic concentration as a function of depth within the MMC which is further described in Section 4.2.1. Concentrations of arsenic in the Cape May Formation sands underlying the MMC are all well below 300 ppm and are consistent with recognized natural background concentrations. These data support the concept that the primary source of arsenic impacts to groundwater is the White Material. Arsenic is mobilized from the White Material and transported into the MMC-Clay in the aqueous-phase and is then partitioned into the solid-phase in the MMC-Clay and sequestered.

3.4 Summary of Hydrogeologic Setting and Groundwater Chemistry

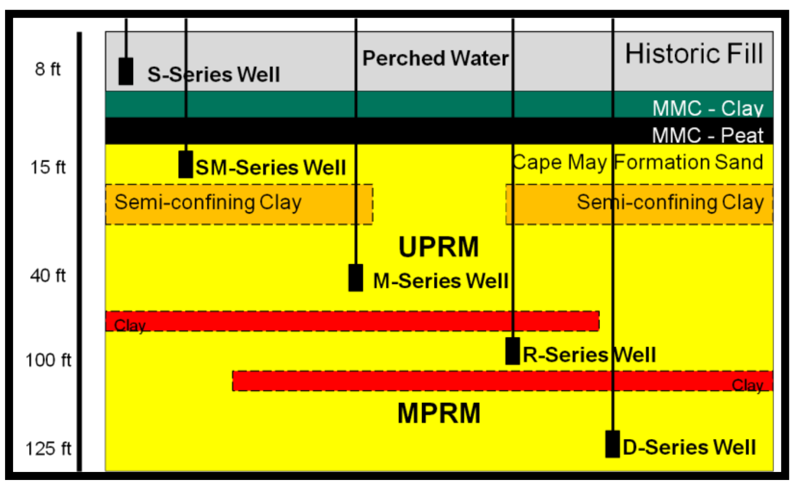


Figure 6 General depth (feet bgs) and nomenclature for the Site monitoring wells

Figure 6 illustrates the general depth and nomenclature for the monitoring wells that previously existed (S-Series) and currently exist at the Site. The decommissioned S-Series monitoring wells were screened above, into, or through the MMC, and generally monitored the perched groundwater that exists above the MMC. The newly constructed SM-series wells were installed to monitor the groundwater directly below the MMC within the Cape May Formation. M-Series wells monitor the UPRM below the semi-confining clay. R-Series wells monitor the transition zone between the UPRM and the Middle-PRM (MPRM) where a series of clay stringers exist and act together as an aquitard. The D-series wells monitor the MPRM.

The overall Site hydrogeologic setting is defined by three hydrostratigraphic units on the Site which include the following:

- Perched Water above the MMC-Clay
- Semi-confined groundwater within the Cape May Formation locally confined between MMC and underlying clay as shown in cross-sections provided in Attachment 1
- UPRM Aquifer (below semi-confining clay)
- MPRM Aquifer (not described in Sections below)

3.4.1 Perched Water

The MMC-Clay acts locally as an aquiclude (hydraulic conductivity of the MMC measured at $5x10^{-6}$ cm/s) and generates a perched shallow groundwater water condition. This perched water has been observed as a thin veneer of saturation directly at the MMC-Clay-Historic Fill contact. The former S-Series wells at the Site generally sampled this water as they were screened either above the MMC-Clay, within the MMC-Clay, or across the MMC unit. These details, along with the rational to abandon the S-Series Wells and replace them with SM-Series Wells is documented in the November 2009 Technical Memorandum[12]. Based on water level data from S-series wells, the surface of the perched water has been interpreted (Figure 7). The general flow potential of perched water is driven by the topography of the top of the MMC-Clay surface. Two localized low spots exist in the central portion of the Site and overall the MMC clay surface dips to the north of the Site toward a low point along the historic Line Ditch[13]. Impacts to perched water monitored by S-series wells likely have originated by contact with White Material and movement along the MMC-Clay surface.

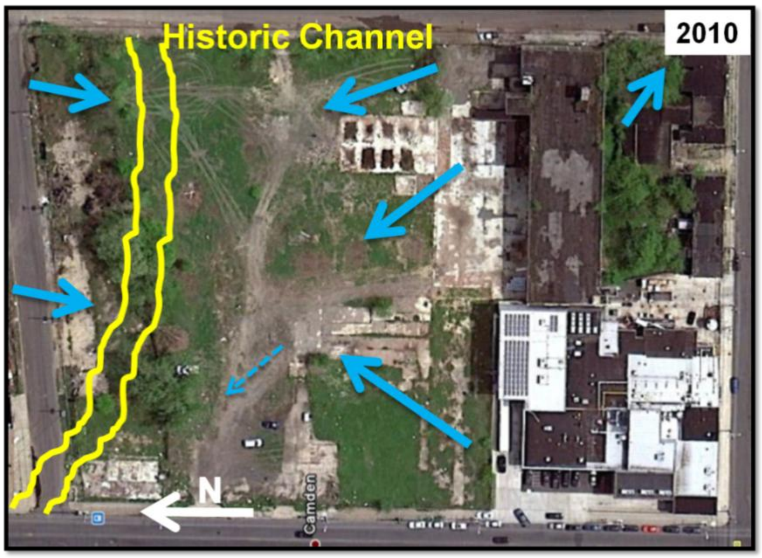


Figure 7 Interpreted groundwater flow direction of perched water above the MMC

[12] *Proposed Abandonment of Fourteen S-Series Monitoring Wells and Construction of Seven SM-Series Monitoring Wells at the Martin Aaron Superfund Site in Camden, NJ*

[13] The "Line Ditch" (as seen on historic Sanborn Maps) traverses the northern part of the Site and most likely marks the location of the former channel that occupied the tidal embayment.

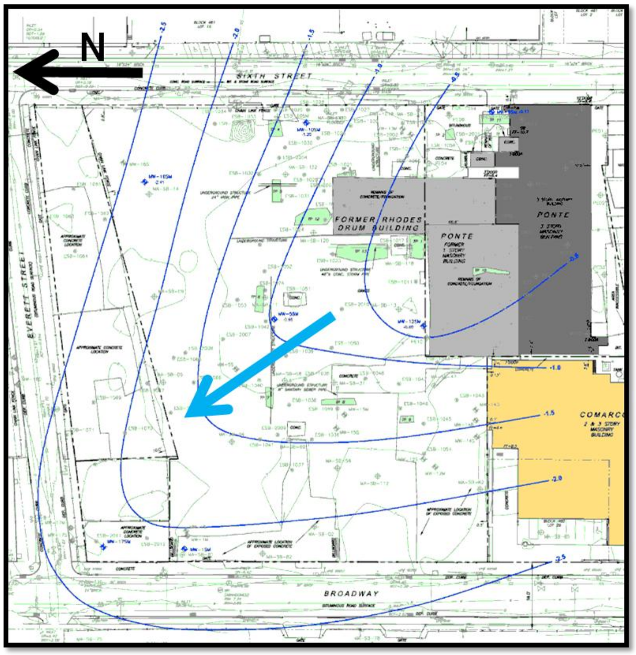


Figure 8 Potentiometric surface map based on SM-Series water level data

3.4.2 Cape May Formation

Installation of the SM-Series wells on-Site (in accordance with the November 2009 Technical Memorandum) provided the first monitoring of groundwater in the Cape May Formation which exhibits semi-confined water-bearing characteristics. Based on the boring information collected during the 2009 PDI, the Cape May Formation is interpreted to begin below the MMC-Peat and extend approximately 2 to 8 feet to an underlying semi-continuous clay[14] unit. The formation generally pinches-out to the south and east at the Site (see cross-sections). The potentiometric surface map (Figure 8), interpreted from water level data collected from the SM-Series wells, suggests that groundwater flow in this hydrostratigraphic unit is toward the north and west of the Site. The flow in this unit appears to be driven by the topography of the semi-confining clay unit and its absence in the northern portion of the Site where it is in hydraulic communication with the UPRM.

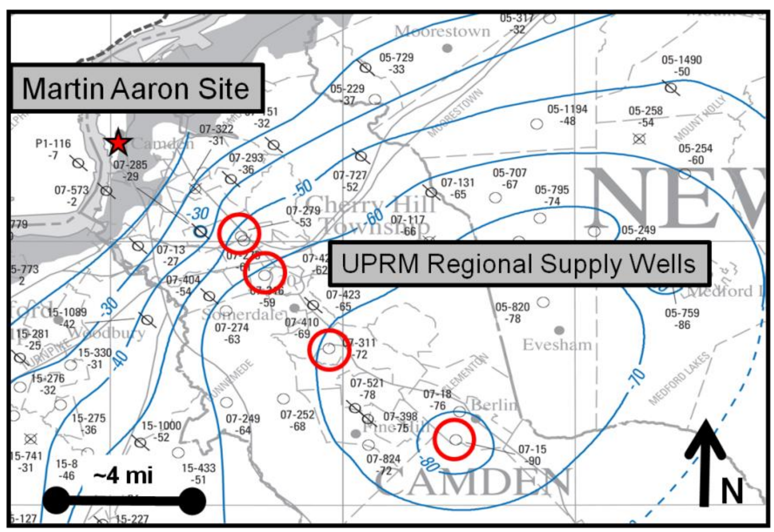


Figure 9 - Regional potentiometric surface of the UPRM aquifer

The limited impacts to the Cape May Formation are believed to have resulted from industrial development of the Site which caused discrete and localized penetrations (utilities and building foundations) of the MMC and together with previous monitoring well installations (S-series) allowed impacted perched water (which had contacted the White Material arsenic source) to migrate through the MMC penetrations into the underlying Cape May Formation. These chemical impacts in the Cape May Formation are generally separated from the UPRM by the Semi-Confining Clay unit.

[14] This clay unit is competent, hard orange clay that is distinct from the MMC-Clay above.

3.4.3 UPRM

Regional groundwater flow within the UPRM is controlled by a series of UPRM regional water supply pumping wells located to the southeast of the city of Camden. The nearest of these regional pumping wells is approximately 4.5 miles from the Site. The regional potentiometric surface map for the UPRM aquifer is shown in Figure 9[15] and clearly illustrates the influence of regional pumping.

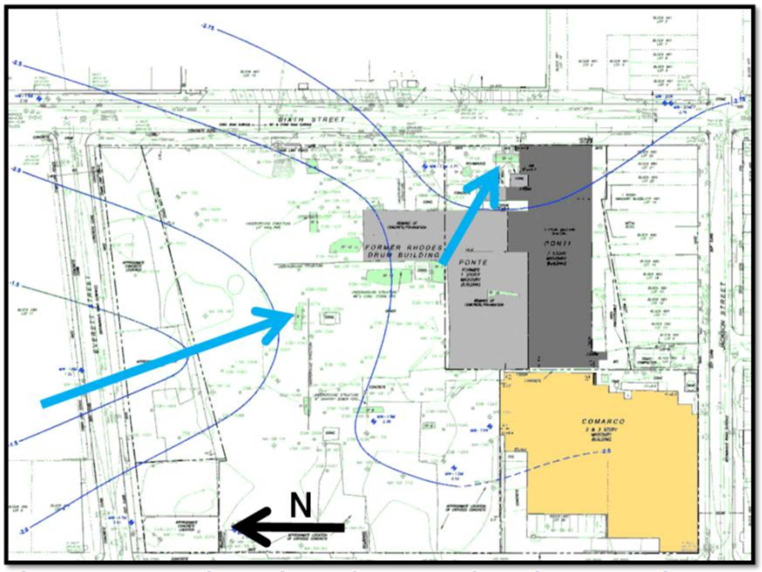


Figure 10 Potentiometric surface map based on M-Series water level data

The Upper PRM is monitored by the M-Series monitoring wells on-Site. The potentiometric surface map (Figure 10), interpreted from water level data collected from the M-Series wells, suggests that groundwater flow in this hydrostratigraphic unit is consistent with regional groundwater flow toward the southeast.

Only minor chemical impacts have been observed below the semi-confining clay within the Upper PRM. The potentiometric surface maps for the Cape May Formation and UPRM can be found in full size in Attachment 1.

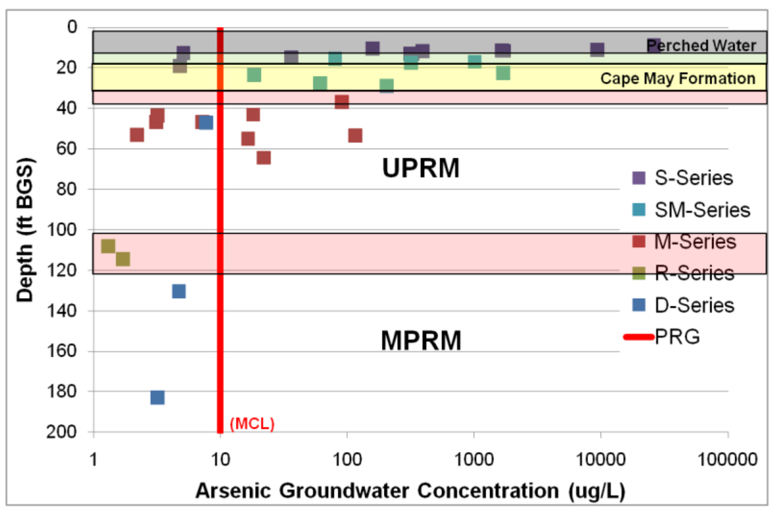


Figure 11 Summary of arsenic groundwater chemistry

3.4.4 Arsenic Groundwater Chemistry

A table including all of the arsenic groundwater chemistry data can be found in Attachment 2. In addition, a figure showing historic arsenic groundwater data collected from 1997 through 2010 using chemistry boxes is provided in Attachment 1. Figure 11 illustrates the arsenic groundwater chemistry collected during the latest groundwater sampling event in 2010 along with the final sampling event performed on the S-series monitoring wells prior to their decommissioning (2009). The figure illustrates the arsenic chemistry trend as a function of depth as it is sampled by the 5 different series of monitoring wells. The most significant

[15] dePaul, V.T., Rosman, Robert, and Lacombe, P.J., 2009, *Water-level conditions in selected confined aquifers of the New Jersey and Delaware Coastal Plain, 2003*: U.S. Geological Survey Scientific Investigations Report 2008-5145, 123 p., 9 pl.

arsenic groundwater impacts are primarily constrained to the S-series monitoring wells and lesser amounts in the SM-series monitoring wells. It is important to note that the SM-series monitoring wells are sampling water that exists in a semi-confined water bearing unit that has been in hydraulic connection with the perched groundwater above the MMC via the S-series wells (for more than 10 years) and possible other discrete penetrations of the MMC (for more than 80 years). There are some limited impacts to groundwater in the UPRM, as sampled by the M-Series monitoring wells, however, the concentration of arsenic is generally near or below the maximum contaminant level (MCL) of 10 µg/kg. The groundwater sampled by the R-Series and D-Series monitoring wells are all below the MCL, suggesting that there is no impact to the transition zone between the UPRM and the MPRM aquifers. It is also important to note that there are no concentrations of arsenic above 10 mg/L in any off-Site, down-gradient, UPRM monitoring wells.

4.0 ARSENIC NATURAL ATTENUATION EVALUATION

4.1 Methodology

The following methodology was used to determine the arsenic natural attenuation mechanisms and capacity, and long-term stability of attenuated arsenic within the MMC. This study required analytical measurements conducted on aqueous- and solid-phase samples collected on-Site. Consistent with USEPA Guidance[16] and technical discussions between Golder and USEPA experts in Aida, Oklahoma, the techniques included determination of total arsenic concentration within the MMC at high vertical resolution, as well as determination of aqueous- and solid-phase partitioning of arsenic and other important geochemical parameters and mineralogical components of the system that are involved in attenuation reactions. The samples collected and applied measurements had both the spatial and temporal resolution to adequately characterize the heterogeneity of conditions on-Site.

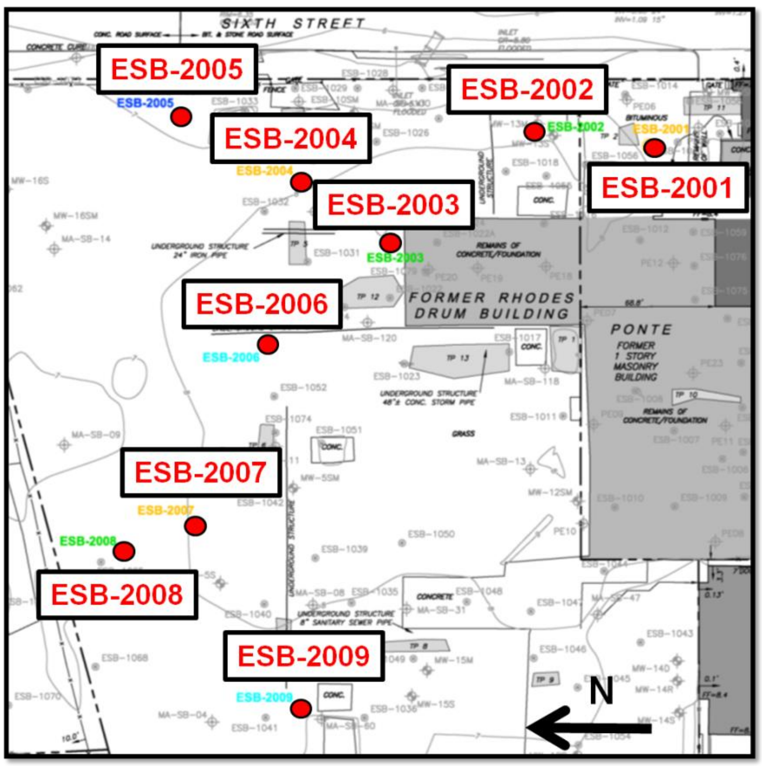


Figure 12 Boring location map for the MMC Stratification Program

4.1.1 MMC Stratification Program

The December 2009 Technical Memorandum[17] contained the following objectives and procedures for the MMC Arsenic Stratification Program:

- Designed to provide data concerning the solid-phase distribution of arsenic, above, below, and within the MMC for use during the arsenic natural attenuation evaluation. Nine soil borings conducted using sonic drilling techniques (Figure 12).
- Arsenic samples were collected at high vertical resolution (6-inch intervals) within the MMC to evaluate vertical stratification of arsenic concentrations
- Arsenic concentration data was collected from a 1-foot interval of White Material (if present) above the MMC to evaluate source concentrations and in the 1-foot interval of Cape May Formation below the MMC contact to evaluate protectiveness of the MMC

[16] USEPA. 2007. *Monitored Natural Attenuation of Inorganic Contaminants in Groundwater*, Volumes 1 and 2.
[17] Golder Associates Inc. 2009. *Technical Memorandum Regarding the Procedure for Evaluating the Stratification of Arsenic within the Meadow Mat Complex at the Martin Aaron Superfund Site, Camden, NJ*

4.1.2 MMC Geochemistry Program

The USEPA approval letter for the December 2009 Technical Memorandum[17], indicated that additional evaluations of the MMC would be necessary, specifically to assess the arsenic binding mechanisms and capacity and the long-term stability of the bound arsenic within the MMC.

Addendum No. 1[18] to the December 2009 Technical Memorandum contained the following objectives and procedures for the MMC Geochemistry Program:

- Designed to provide a comprehensive set of geochemical data to determine the mechanisms controlling arsenic solid-phase partitioning within the MMC
- Samples collected from the MMC as part of the Stratification Program were analyzed to define the geochemical conditions
- Geochemical samples were analyzed for the following:
  - total iron
  - total sulfur
  - total organic carbon (TOC)
  - pH
- Eighteen samples (one sample each from the clay portion of the MMC and the peat portion of the MMC at nine locations) were collected and archived at the laboratory for analyses as part of the MMC stability program described below. These samples were carefully managed using anoxic preservation techniques (to maintain the *in situ* redox condition) and were sealed and stored frozen at -20 °C until the time of analysis[19] described below

4.1.3 MMC Stability Program

Addendum No. 2[20] to the December 2009 Technical Memorandum contained the following objectives and procedures for the MMC Arsenic Stability Evaluation Program:

- Designed to provide data to evaluate the aquifer solids mineralogy and solid-phase arsenic partitioning within the MMC
- Samples collected from the MMC as part of the above Geochemistry Program that had been archived and preserved were analyzed using a Sequential Extraction Procedure (SEP)
- Arsenic Stability samples were analyzed using the following five-step SEP[21]
  - Step 1 - Extraction using ammonium sulfate [$(NH_4)_2SO_4$] (0.05 M); soil:solution ratio (SSR) of 1:25

[18] Golder Associates Inc. 2010. *Addendum No. 1 to Procedure for Evaluating the Stratification of Arsenic Within the Meadow Mat Complex at the Martin Aaron Superfund Site, Camden, NJ*
[19] Samples were collected in accordance with the U.S. Environmental Protection Agency (2006) *Mineralogical Preservation of Solid Samples Collected from Anoxic Subsurface Environments.* EPA Groundwater Issue. USEPA National Risk Management Research Laboratory, EPA/600/R-06/112, Cincinnati, OH
[20] Golder Associates Inc. 2010. *Addendum No. 2 to Procedure for Evaluating the Stratification of Arsenic Within the Meadow Mat Complex at the Martin Aaron Superfund Site, Camden, NJ*
[21] The SEP selected for the Site is that described in Wenzel, W.W., N. Kirchbaumer, T. Prohaska, G. Stingeder, E. Lombi, and D.C. Adriano. *Arsenic fractionation in soils using an improved sequential extraction procedure.* Analytica Chimica Acta 436: 309-323 (2001)

  - Operationally defined to represent non-specifically sorbed arsenic, for example arsenic that is weakly bound via electrostatic interaction and can easily be displaced by counter ions. The likely mechanism for arsenic mobilization is anion exchange.
- Step 2 - Extraction using ammonium phosphate [$(NH_4)H_2PO_4$] (0.05 M); SSR of 1:25
  - Operationally defined to represent specifically sorbed arsenic, for example arsenic that is strongly complexed with iron oxides or with humic and fulvic fractions of organic matter, but can still be displaced competitively by phosphate. The likely mechanism for arsenic mobilization is anion exchange.
- Step 3 – Extraction using NH_4-oxalate buffer (0.2 M); pH 3.25; SSR of 1:25
  - Operationally defined to represent arsenic associated with amorphous and poorly crystalline hydrous oxides of iron and aluminum, for example arsenic that is co-precipitated with these phases. The likely mechanism for arsenic mobilization is ligand-promoted dissolution[22].
- Step 4 – Extraction using NH_4-oxalate buffer (0.2 M) and ascorbic acid (0.1 M); pH 3.25; SSR of 1:25
  - Operationally defined to represent arsenic associated with well-crystallized hydrous oxides of iron and aluminum, for example arsenic that is co-precipitated with these phases. The likely mechanism for arsenic mobilization is ligand-promoted dissolution.
- Step 5 – Extraction using hot nitric acid [HNO_3]/hydrogen peroxide [H_2O_2]; SSR of 1:50 (microwave digestion)
  - Operationally defined to represent arsenic associated with residual phases. The likely mechanism for arsenic mobilization is complete oxidation of sulfides (if any), silicates, and recalcitrant organic material.

Sequential extraction was used as the primary technique to assess environmental availability of arsenic at the Site (binding mechanism, capacity and stability). The sequential extraction procedure detailed above involves exposing the MMC samples to a successively harsher solution thus determining the geochemical conditions under which arsenic can be dissolved, and therefore, potentially mobilized in groundwater. The concept is that the soil matrix is composed of a series of specific mineralogical fractions that are capable of binding arsenic either through adsorption or co-precipitation. Each mineralogical fraction has its own specific stability and capacity for sequestering arsenic. Measuring the amount of arsenic released under exposure to increasingly aggressive extraction conditions allows one to estimate the general association of arsenic with the mineralogy of the Site soils and the mechanism of partitioning of arsenic to the solid phase. Information from the sequential extraction program can be compared to site geochemical parameters to evaluate the influence of redox and pH on the long-term stability of arsenic in the MMC.

[22] In coordination chemistry, a ligand is an ion or molecule that binds to a central metal atom to form a coordination complex. Ligands (e.g., oxalate) are known to promote the dissolution of oxide minerals (e.g., iron oxides) through a surface-controlled reaction where the oxalate surface complex formation facilitates release of iron from the oxide mineral surface into solution. For further information see Stumm, W. 1992. *Chemistry of the Solid-Water Interface; Processes at the Mineral-Water and Particle-Water Interface in Natural Systems*. Wiley Interscience.

4.1.4 Data Quality Assurance

The basic principles of analytical quality assurance (QA) and quality control (QC), as outlined in the site specific Quality Assurance Project Plan (QAPP) for the collection of groundwater natural attenuation parameters, was followed in generating the natural attenuation data for arsenic in the MMC. This included the laboratory applying standard analytical operating procedures developed for each method, which also involved assessing principal QC elements in generating quality data. The specific QC elements applied to the data, to assess precision and accuracy control, included instrument calibration, method blank analysis, a blank spike analysis, and a field duplicate analysis. The results were determined by the Golder QA officer to be useable for its intended objectives, as described herein.

4.2 Summary of Results

4.2.1 MMC Stratification Program

Figure 13 below presents an example of the results of the Stratification Program for boring ESB-2001. The figure has been color-coded to represent the material type in which each sample was collected and the axes of the plot show the depth (bgs) and arsenic concentration in parts per million (mg/kg). Light grey highlighting represents the Historic Fill. White highlighting represents White Material. Light green highlighting represents MMC-Clay. Dark green highlighting represents MMC-Peat. Yellow highlighting represents Cape May Formation sand. A vertical red line illustrates the 300 mg/kg PRG. An inset is provided to detail results below 300 mg/kg. A set of figures similar to Figure 13 for each of the borings in the Stratification Program is included in Attachment 3 showing similar results.

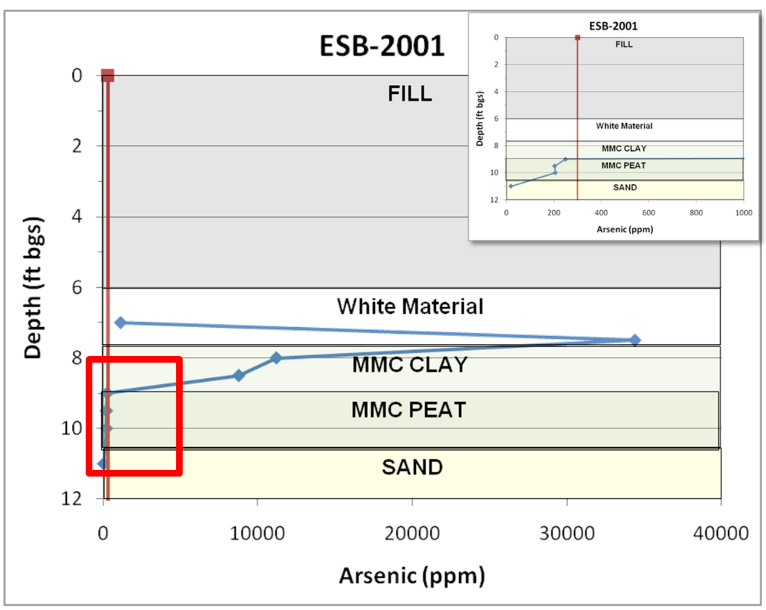


Figure 13 Arsenic soil chemistry results from the Stratification Program for boring ESB-2001

It is clear from Figure 13 that arsenic concentrations greater than 300 mg/kg exist in boring ESB-2001 only within the White Material and the MMC-Clay. This concentration profile indicates that the arsenic concentration within the White Material has been depleted. The White Material is depleted due to long-term dissolution and transport of arsenic from this primary source material into the MMC-Clay. The concentration of arsenic in the uppermost portion of the MMC-Clay (34,000 mg/kg) reflects the significant capacity that the MMC has to sequester arsenic. This is further established by the clear stratification in the results with elevated concentrations existing in the shallow MMC-Clay samples and decreasing rapidly as a function of depth. The MMC-Peat samples and Cape May Formation sand sample do not exceeded 300 mg/kg arsenic. As stated previously, arsenic concentrations in Cape May Formation sand are near natural background levels.

4.2.2 Geochemistry Program

Figures 14 through 18 illustrate the results of the geochemical analysis performed on both the MMC-Clay and MMC-Peat components. The data for total sulfur is not shown graphically as all of the results for total sulfur were non-detect (detection limit of 0.5% of the analyzed sample mass). All of the data for the geochemistry program can be found in Attachment 2.

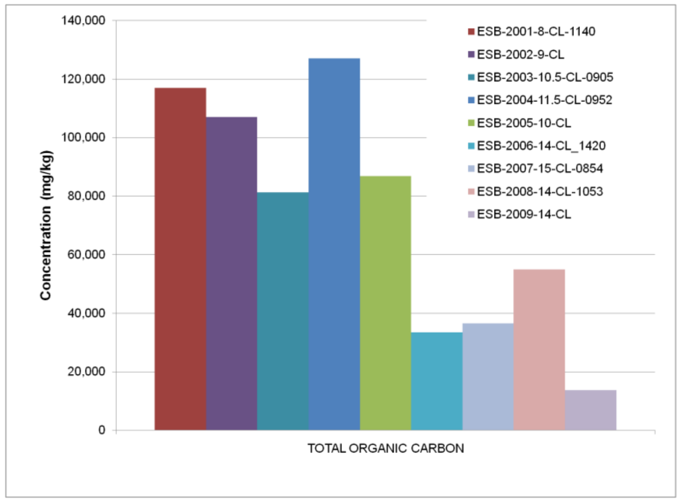


Figure 14 TOC results from the MMC-Clay samples

4.2.2.1 Total Organic Carbon

The geochemical analysis in both MMC-Clay and MMC-Peat reflects that there is a significant concentration of total organic carbon (TOC) present in these units (Figure 14 and Figure 15). The high concentration of TOC present in the samples represents a source reducing potential (i.e., the degradation of organic carbon is an oxidative process which may result in overall generation of reducing conditions). However, the presence of the MMC and its interaction with the White Material has existed for well over 100 years. The groundwater and solid-phase system within the MMC has clearly reached an equilibrium state where the reducing potential is either buffered or is not accessible. With that in mind, it is also highly unlikely that significant changes to the overall geochemical condition in these two units are possible based on this historic stability. Elevated TOC in the MMC is the result of the burial of naturally occurring root and plant matter from the historic tidal embayment. It is also possible that organic matter from the placement of the White Material may have been incorporated into the MMC. This organic matter could contain recalcitrant material that is not easily

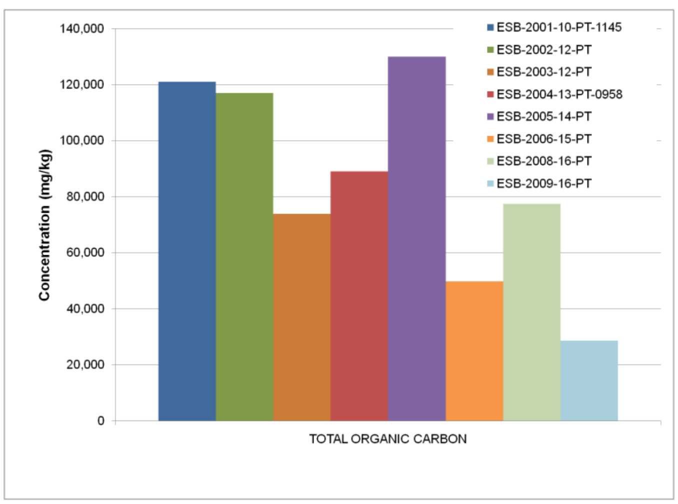


Figure 15 TOC results from the MMC-Peat samples

degradable. As will be discussed later in the Stability Program, association of arsenic with recalcitrant organic material may explain the elevated concentration of arsenic present in the recalcitrant sequential extraction step.

4.2.2.2 Iron

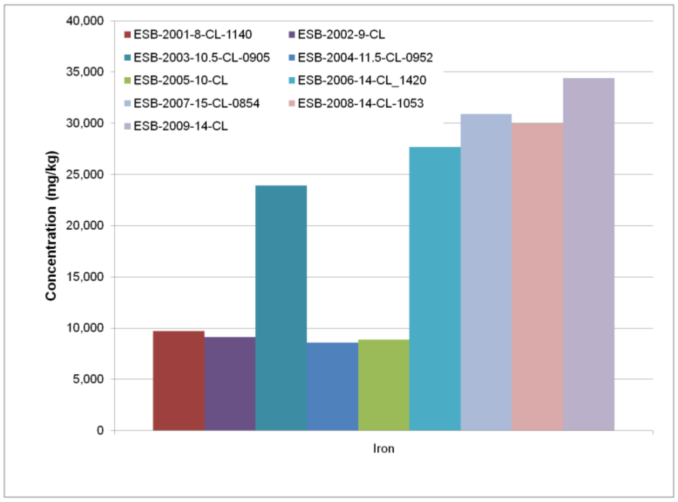


Figure 16 Total iron results from the MMC-Clay samples

The geochemical analysis in both MMC-Clay and MMC-Peat suggest that there is a significant concentration of total iron in these units (Figure 16 and Figure 17). The presence of significant amounts of iron in these units represents a reactive mineral phase that is capable of adsorbing significant concentrations of arsenic. Under near-neutral pH conditions, and oxidizing ORP conditions, the sorption of arsenate (As^{V}) onto iron oxides will occur. For example, adsorption to iron oxyhydroxides, e.g., goethite (a-FeOOH), can occur. With more reducing ORP conditions, sorption of arsenate (As^{V}), or arsenite (As^{III}), to reduced iron-bearing minerals can occur. These mineral phases may include magnetite [$Fe^{III}_2Fe^{II}O_4$] or green rust [$Fe^{II}_6Fe^{III}_2(OH)_{18}\bullet 4(H_2O)$].

Again, based on the relative age of these impacts (well over 100 years) the system has clearly reached an equilibrium state where iron oxide mineral phases are stable. With that in mind, it is unlikely that significant changes to the overall geochemical condition in these two units are possible and, therefore, arsenic bound within the iron oxide mineral phases would continue to be stable.

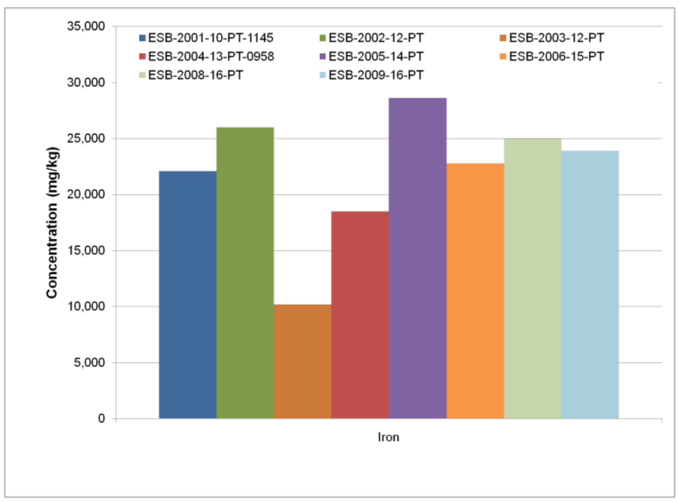


Figure 17 Total iron results from the MMC-Peat samples

4.2.2.3 pH

The data establishes that MMC-Clay samples, particularly those near the contact between White Material and the MMC, exhibit elevated pH conditions. This may be a result of the chemistry of the White Material which is likely a lime-rich material and anticipated to generate alkaline pH conditions. Overall, the general pH conditions in both units are near-neutral to slightly alkaline as shown in Figure 18. These conditions would likely not allow the pH to decrease to levels utilized in the last three sequential extraction steps (i.e., pH <3.25).

4.2.2.4 Summary

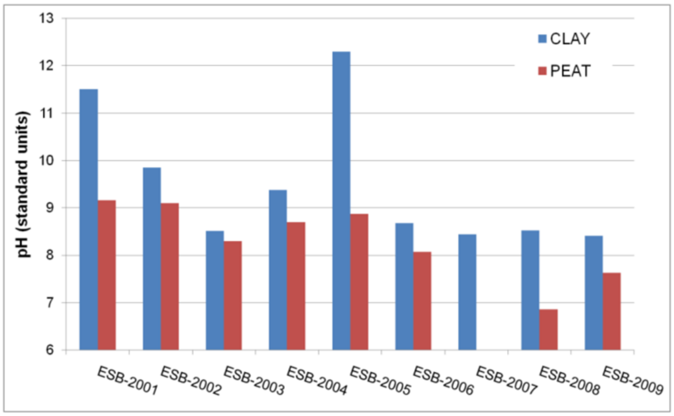


Figure 18 Results of pH analysis for MMC-Clay and MMC-Peat samples

Figure 19 shows Eh-pH diagrams for arsenic and iron at 25°C for iron-reducing systems. These figures show the relative distribution of potentially adsorbing arsenic species (Figure A) relative to representative types of iron-bearing sorbents (Figure B) that are predicted to occur as a function of Eh and pH[23]. The red highlighted area represents the general pH condition at the Site and the corresponding arsenic speciation and iron-bearing mineral phases that may exist. Based on the results of the geochemistry program, arsenic likely exists as arsenate (in the $HAsO_4^{2-}$ form) and is strongly associated with goethite (α-FeOOH) or amorphous iron oxyhydroxide phases.

It is important to note that based on the geochemical evaluation, in particular the pH condition of the MMC, it would require a significant perturbation in the system to cause pH levels to drop from 7 to 9 standard units to below 3.5 to 4 standard units and promote the dissolution of iron oxide mineral phases. Therefore, the geochemical evaluation supports the concept that arsenic is being attenuated in the MMC through association with mineral phases that are present and the long-term stability of these phases is anticipated based on historic stability of the system and the unlikelihood of significant changes to the pH or oxidation state of the system in the future.

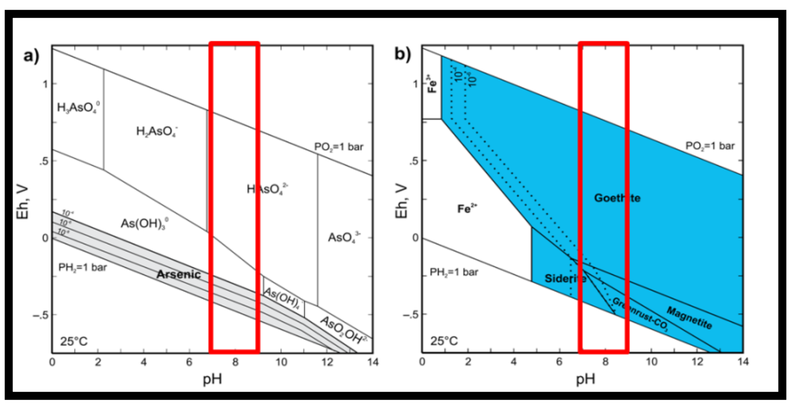


Figure 19 Eh-pH diagrams for arsenic and iron at 25°C for iron-reducing systems

4.3 Stability Program

Arsenic stability is defined by the processes that control arsenic mobility in groundwater and the capacity and longevity of the system to sequester arsenic. To determine arsenic stability it is critical to understand

[23] Taken from USEPA. 2007. *Monitored Natural Attenuation of Inorganic Contaminants in Groundwater*, Volumes 2. Figure (a) System As-H_2O, with ΣAs contoured from 10^{-8} to 10^{-4}; region for elemental arsenic is shaded gray. Figure (b) System Fe-C-H_2O (no sulfur) with ΣFe contoured from 10^{-2} to 10^{-6} and $\Sigma C=10^{-3}$; Hematite and Wüstite are suppressed.

the chemical processes that control the partitioning of arsenic onto aquifer solids. The results of the sequential extraction study allow an assessment of these processes from a mechanistic standpoint. This information, together with the geochemical results presented in Section 4.2 above, can also be used to assess potential changes in mobility that may occur as a function of changes in the geochemistry of the groundwater system.

There are a number of geochemical factors that control arsenic fate and transport in the environment. Some of the geochemical factors that control the re-mobilization of arsenic include the following:

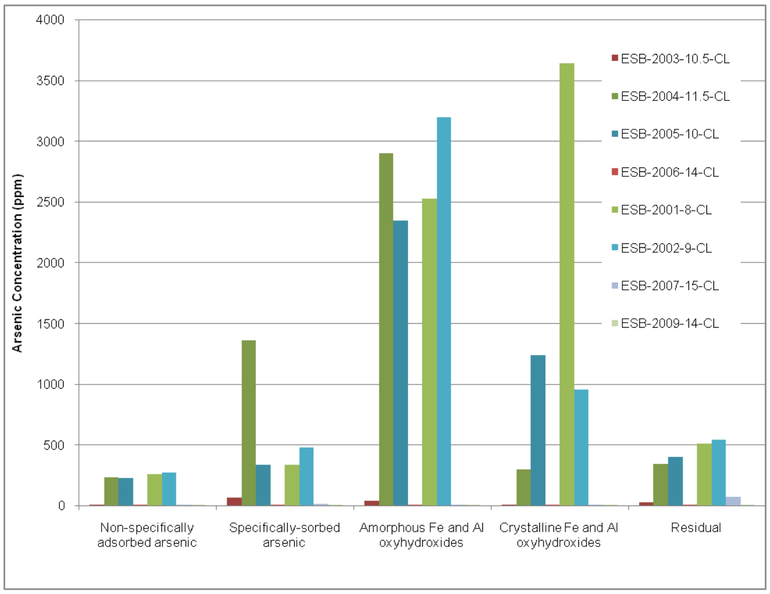


Figure 20 Results of sequential extraction analysis of MMC-Clay

- Desorption at low pH under oxidizing conditions and/or due to the influx of dissolved ions that compete for sorption sites on aquifer minerals
- Desorption/ dissolution due to a change to the redox condition

The first geochemical factor is a result of the influx of dissolved constituents that compete for, or displace, arsenic adsorbed to mineral surfaces without a concomitant change in sorbent stability. The second process is a result of a change in the ground-water chemistry due to a condition under which the sorbent material is no longer stable. This may be a result of a change in redox, pH, or other factors leading to dissolution of the sorbent phase[3,24,25].

The complete results of the Stability Program (sequential extraction study) are included in Attachment 4. Overall, the study concluded that arsenic is associated with amorphous, poorly crystalline, and well-crystallized hydrous oxides of iron in the MMC-Clay. The geochemistry data supports this concept as significant concentrations of solid-phase iron have been observed in the MMC-Clay. Aluminum concentrations in the MMC-Clay were not measured as part of this study; however, previous data suggests that aluminum does not make up a significant component of the MMC. The study also concluded that little arsenic is present in the MMC-Peat. This is believed to be due to sequestration in the overlying MMC-Clay component. Geochemically, these two units are similar and therefore it is anticipated

[24] Hounslow, A.W. 1980. *Ground-water geochemistry: arsenic in landfills*. Ground Water 18: 331-333.
[25] Smedley, P.L. and D.G. Kinniburgh. 2002. *A review of the source, behaviour and distribution of arsenic in natural waters*. Applied Geochemistry 17: 517-568.

the MMC-Peat has a similar capacity to the MMC-Clay for solid phase partitioning. Taken further, the MMC-Peat can be considered to have addition sequestering capacity below the MMC-Clay.

Figure 20 shows the result of the sequential extraction procedure for eight samples collected in the MMC-Clay. The figure shows the concentration of arsenic that was recovered during each successive extraction step. The X-axis label shows the operationally defined association of arsenic within the solid phase. Figure 20 shows that the most significant concentrations of arsenic are associated with amorphous, poorly crystalline, and/or well-crystallized hydrous oxides of iron.

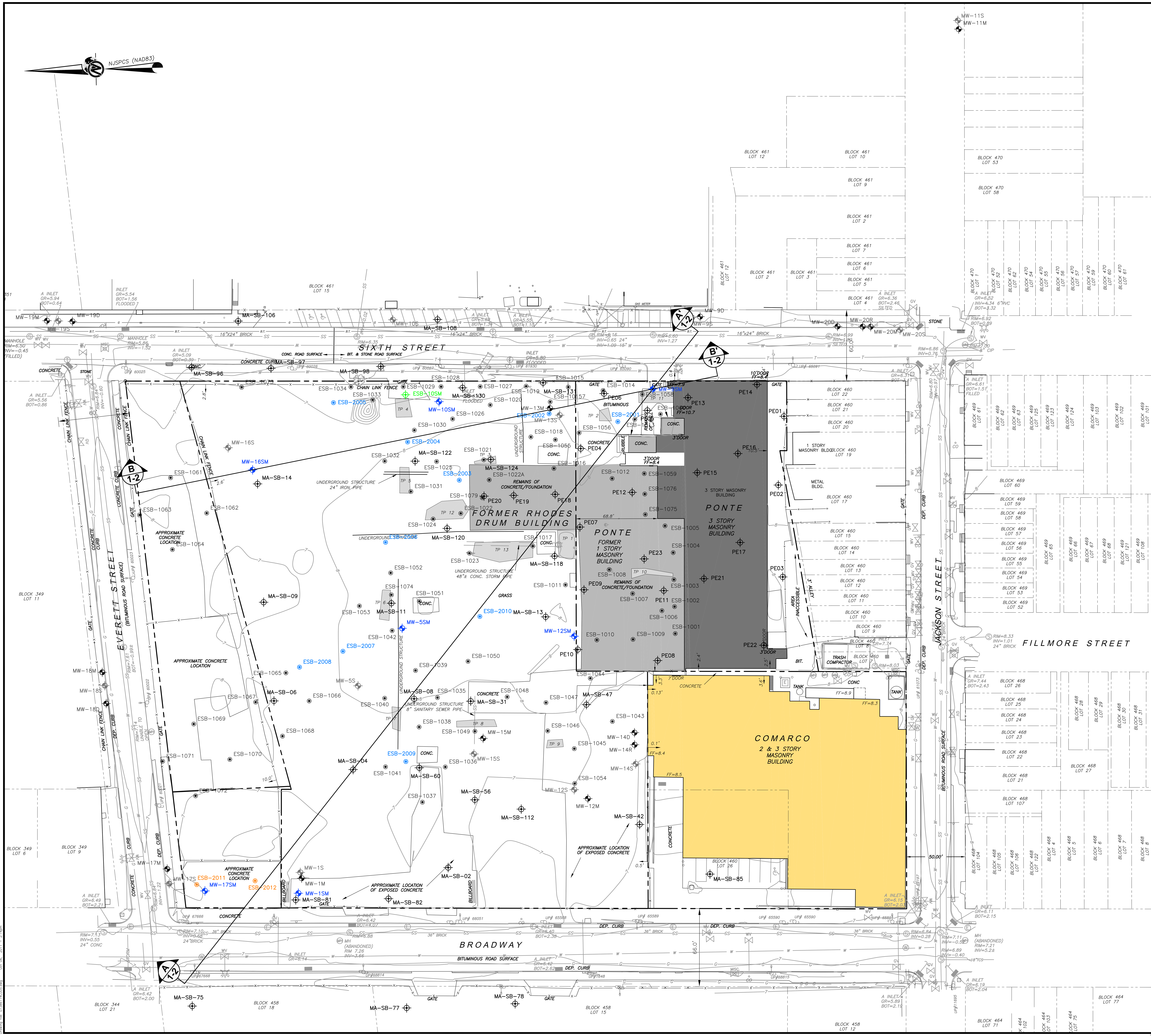
Based on the known geochemistry that controls the stability of iron oxides in the environment, only significant, and highly unlikely, changes in pH or redox condition would negatively influence the current stability of arsenic in this system. For example, the extraction steps (Step 3 and Step 4), which resulted in the most significant mass removal of arsenic from the solid phase, rely on adjusting the pH of the solution to 3.25 along with a strong ligand (oxalate) in Step 3 followed by an even more aggressive acid extraction (ascorbic acid) in Step 4. This suggests that only under acidic pH conditions, and via ligand-promoted dissolution, was the arsenic liberated from the MMC-Clay. It is unlikely, based on the Site history and future redevelopment plans (i.e., commercial or industrial reuse), that a dramatic change in groundwater pH or a significant influx of competitive ions or ligands will occur.

As discussed previously, the current redox condition of the MMC-Clay is less straightforward based on the presence of high TOC levels as measured during the Geochemistry Program. However, the current degree of arsenic stability has existed for well over 100 years. This is based on the results of the Stratification Program which demonstrates that the most significant impacts of arsenic have only migrated into the uppermost portion of the MMC-Clay. Although there appears to be significant reductive potential due to the high TOC, the system appears to have reached equilibrium where the reducing potential is buffered or is not accessible.

5.0 CONCLUSION

The natural attenuation capacity of the MMC was evaluated through the performance of a comprehensive stratification, geochemistry, and arsenic stability study. The presence of solid-phase arsenic impacts in the MMC is observed to be highly vertically stratified and exists primarily in the uppermost portion of the MMC. Geochemistry data demonstrate that significant iron and TOC are present in the MMC and likely control the solid-phase partitioning of arsenic. Sequential extraction data indicate that arsenic in the MMC is present in stable mineral phases associated with amorphous, poorly crystalline, and crystalline iron oxides. Arsenic sequestered within the MMC will remain immobile under any reasonably-conceivable set of future hydrogeological and/or geochemical conditions. Therefore, there is no scientific justification to remove the MMC. Moreover, leaving the MMC in place allows this unit to continue to act as a natural hydraulic and reactive barrier with respect to groundwater quality at, and/or in the vicinity of, the Site.

ATTACHMENT 1



LEGEND

- PROPERTY LINE
- ADJOINING PROPERTY LINE
- RAILROAD TRACK
- CHAIN LINK FENCE
- EXISTING CONTOUR
- SEWER/STORM SYSTEM
- COMMUNICATIONS LINE
- ELECTRIC LINE
- GAS LINE
- WATER LINE
- UTILITY POLE
- UTILITY POLE W/LIGHT
- GAS VALVE
- WATER VALVE
- FIRE HYDRANT
- WATER MANHOLE
- INLET
- SEWER/STORM MANHOLE
- CLEAN OUT
- MANHOLE (USE UNKNOWN)
- COMMUNICATIONS MANHOLE
- ELECTRIC MANHOLE
- VALVE-USE UNKNOWN
- MW-20M — EXISTING MONITORING WELL
- MW-5SM — REPLACEMENT SM-SERIES MONITORING WELL (SEE REFERENCE 3)
- MW-20S — ABANDONED MONITORING WELL (S-SERIES WELLS DURING APRIL-MAY 2010 EVENT)
- ESB-10SM — ENVIRONMENTAL SOIL BORING (APRIL-MAY 2010 EVENT)
- PE17 — USEPA POST-ROD INVESTIGATION BORINGS
- MA-SB-120 — USEPA RI BORINGS
- ESB-1011 — ENVIRONMENTAL SOIL BORING - PDI STAGE I (2009)
- ESB-2001 — ENVIRONMENTAL SOIL BORING - STRAT/MMC (2010)
- BAKERY BORING (2010)
- A — DETAIL OR CROSS SECTION DESIGNATION
- 1 — FIGURE No. WHERE DETAIL OR CROSS SECTION IS PRESENTED

REFERENCES

1.) MAP FROM DIGITAL CAD FILE MARTI-AARON-REV3.DWG ENTITLED "MAP OF SURVEY BLOCK 460, LOTS 1, 2, 3, 4, 26, & 29 CITY OF CAMDEN, CAMDEN COUNTY, NEW JERSEY DATED JULY 28, 2009, PREPARED BY VARGO ASSOCIATES.

2.) USEPA BOREHOLE LOCATIONS (OTHER THAN PONTE EQUITIES PROPERTY BOREHOLES) FROM EXCEL FILE Sample Locations.XLS PROVIDED BY de maximis, INC. PONTE EQUITIES PROPERTY BOREHOLE LOCATIONS FROM SOIL BORING LOGS WORK ASSIGNMENT #0-183 FOR THE PONTE EQUITIES SITE, DATED JUNE 1, 2006, PROVIDED BY LOCKHEED MARTIN.

3.) MONITORING WELLS MW-1SM, MW-5SM, MW-9SM, MW-10SM, MW-12SM, MW-16SM MW-17SM AND BORING ESB-10SM FROM WELLS-050310.XLS, SURVEYED ON MAY 3, 2010 BY VARGO ASSOCIATES.

4.) ENVIRONMENTAL SOIL BORINGS ESB-2001 THROUGH ESB-2012 FROM CAD FILE BORINGS-082310.DWG, DATED AUGUST 23, 2010, PROVIDED BY VARGO ASSOCIATES.

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REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT

MARTIN AARON SUPERFUND SITE
CAMDEN, NEW JERSEY

TITLE

CROSS SECTION LOCATION PLAN

NJ Authorization #24GA28029100

Golder Associates
Mt. Laurel, New Jersey

PROJECT No.	073-86114	
DESIGN	JLH	10/06/11
CADD	AM	10/06/11
CHECK	MJB	10/06/11
REVIEW	RSW	10/06/11

FILE No. 07386114C005

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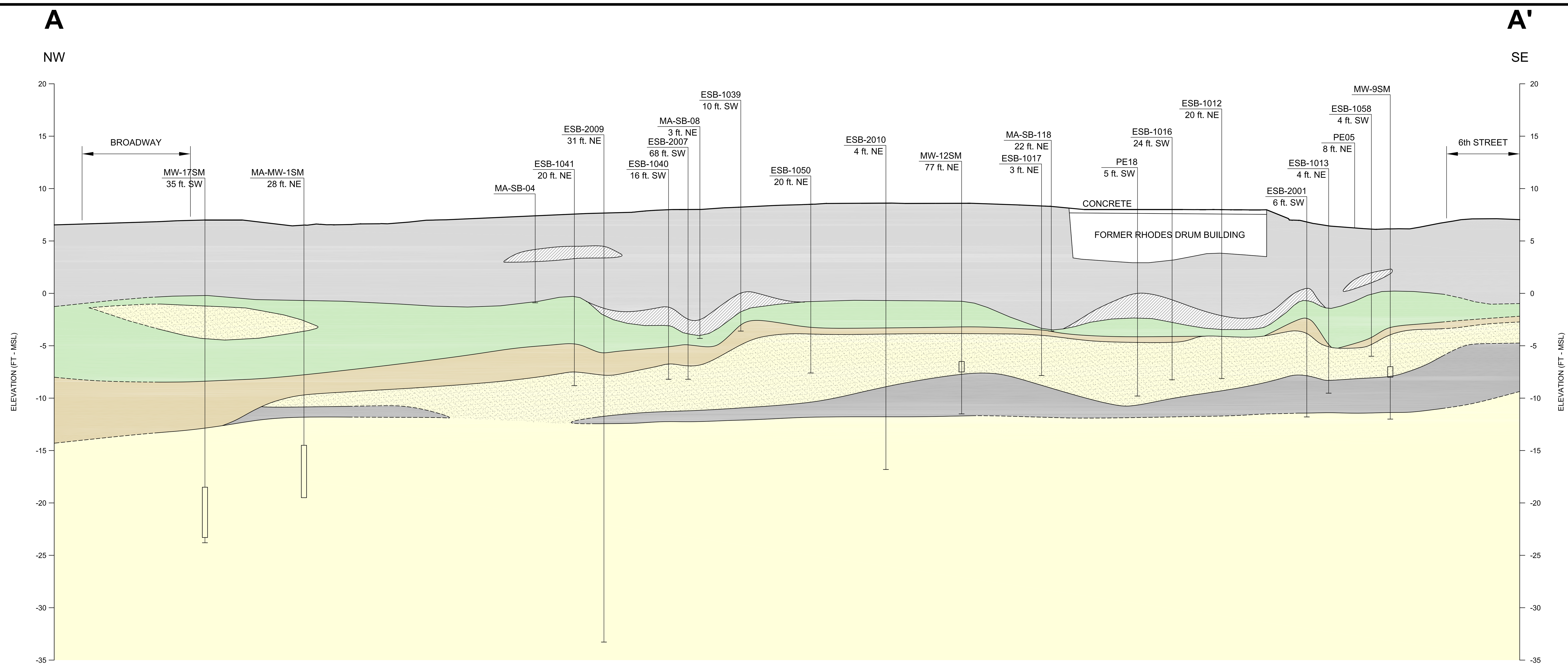
ATTACHMENT 1-1



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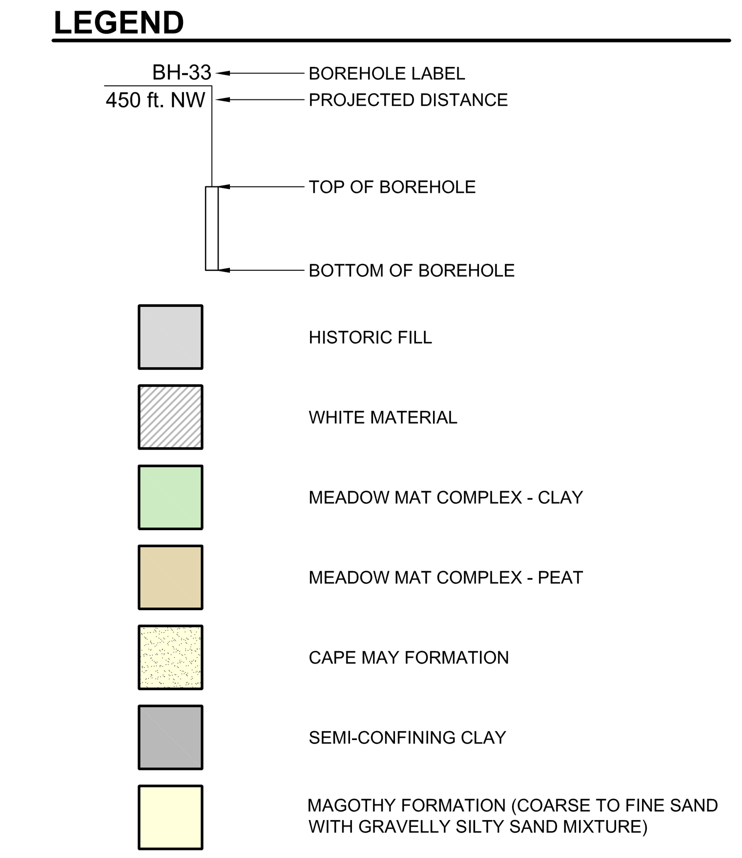

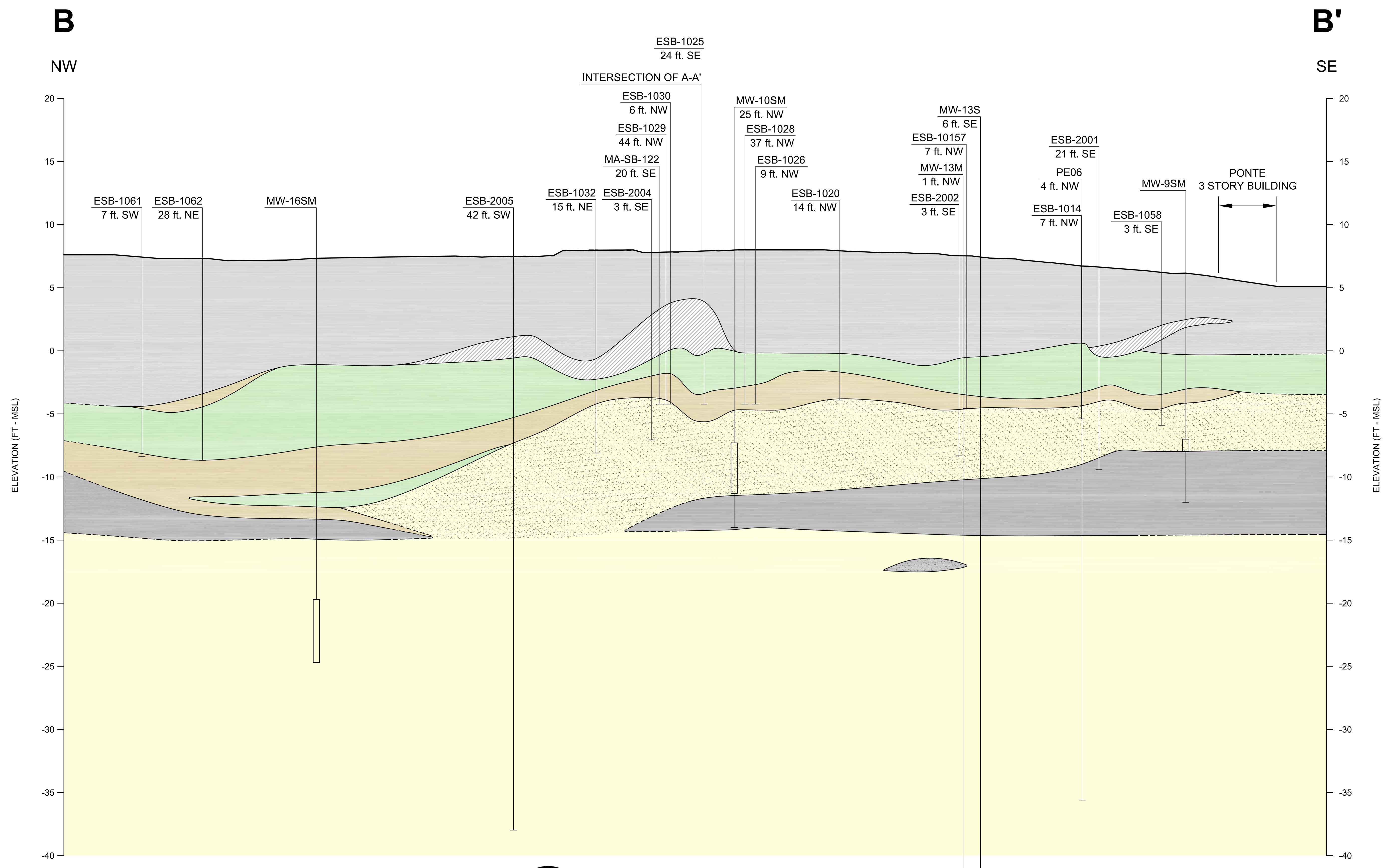

B 1-2 CROSS SECTION B-B'

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VERTICAL SCALE: 5 0 5 10 FEET

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT

MARTIN AARON SUPERFUND SITE
CAMDEN, NEW JERSEY

TITLE

CROSS SECTIONS A-A' AND B-B'

Golder Associates
Mt. Laurel, New Jersey

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REVIEW	RSW	10/06/11		

LEGEND

PROPERTY LINE
ADJOINING PROPERTY LINE
RAILROAD TRACK
CHAIN LINK FENCE
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BAKERY BORING (2010)

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4.) ENVIRONMENTAL SOIL BORINGS ESB-2001 THROUGH ESB-2012 FROM CAD FILE BORINGS-082310.DWG, DATED AUGUST 23, 2010, PROVIDED BY VARGO ASSOCIATES.

THICKNESS OF WHITE MATERIAL	
RANGE	COLOR
0.1' to 1.0'	light blue
1.0' to 2.0'	light green
2.0' to 3.0'	green
3.0' to 4.0'	orange
4.0' >	red

SCALE 30 0 30 60 FEET

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT
MARTIN AARON SUPERFUND SITE
CAMDEN, NEW JERSEY

TITLE
THICKNESS OF WHITE MATERIAL

Golder Associates
Mt. Laurel, New Jersey
NJ Authorization #24GA28029100

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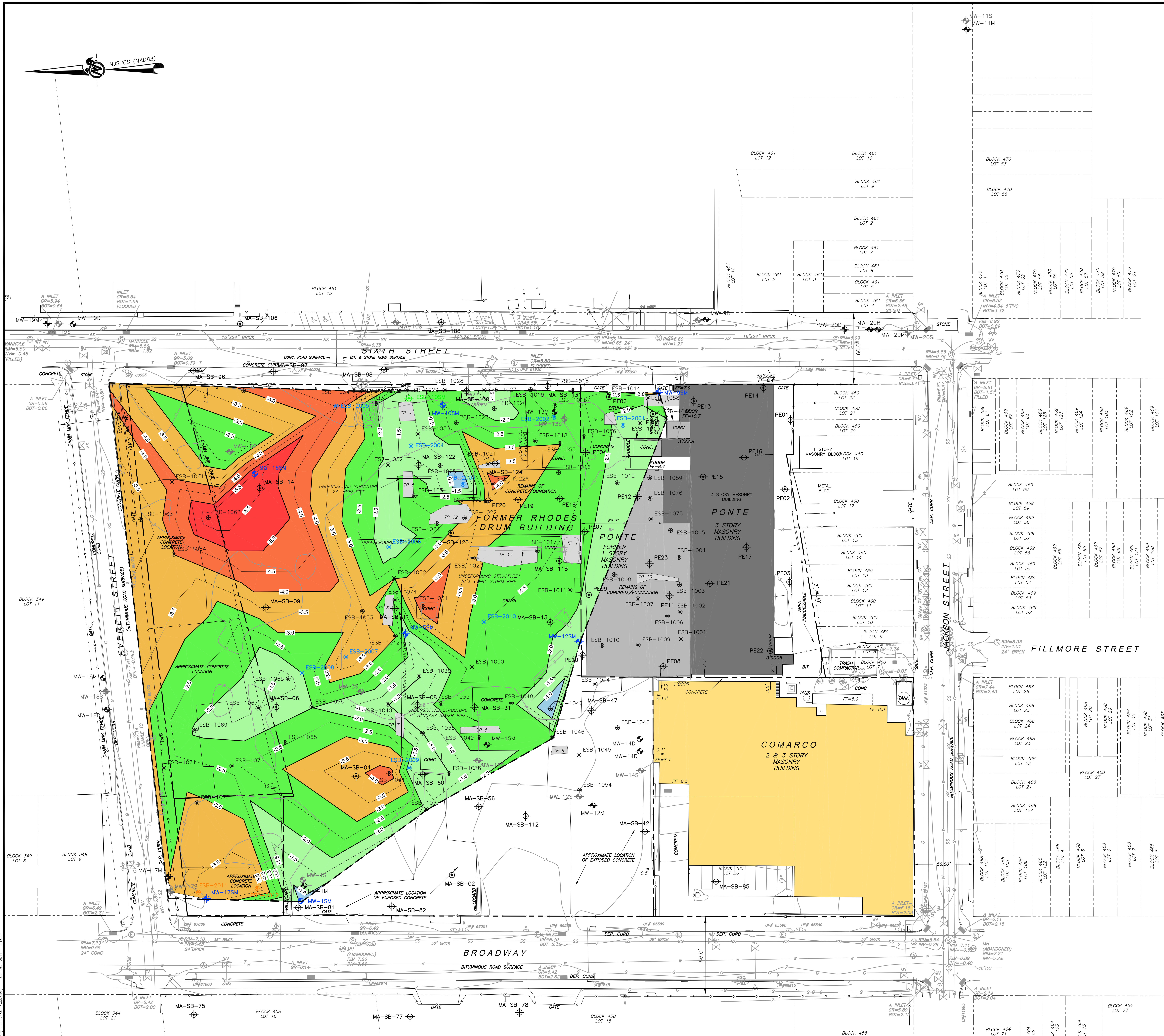

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- ELECTRIC LINE
- GAS LINE
- WATER LINE
- UTILITY POLE
- UTILITY POLE W/LIGHT
- GAS VALVE
- WATER VALVE
- FIRE HYDRANT
- WATER MANHOLE
- INLET
- SEWER/STORM MANHOLE
- CLEAN OUT
- MANHOLE (USE UNKNOWN)
- COMMUNICATIONS MANHOLE
- ELECTRIC MANHOLE
- VALVE-USE UNKNOWN
- MW-20M — EXISTING MONITORING WELL
- MW-5SM — REPLACEMENT SM-SERIES MONITORING WELL (SEE REFERENCE 3)
- MW-20S — ABANDONED MONITORING WELL (S-SERIES WELLS DURING APRIL-MAY 2010 EVENT)
- ESB-10SM — ENVIRONMENTAL SOIL BORING (APRIL-MAY 2010 EVENT)
- PE17 — USEPA POST-ROD INVESTIGATION BORINGS
- MA-SB-120 — USEPA RI BORINGS
- ESB-1011 — ENVIRONMENTAL SOIL BORING – PDI STAGE I (2009)
- ESB-2001 — ENVIRONMENTAL SOIL BORING – STRAT/MMC (2010)
- BAKERY BORING (2010)

REFERENCES

1.) MAP FROM DIGITAL CAD FILE MARTI-AARON-REV3.DWG ENTITLED "MAP OF SURVEY BLOCK 460, LOTS 1, 2, 3, 4, 26, & 29 CITY OF CAMDEN, CAMDEN COUNTY, NEW JERSEY DATED JULY 28, 2009, PREPARED BY VARGO ASSOCIATES.

2.) USEPA BOREHOLE LOCATIONS (OTHER THAN PONTE EQUITIES PROPERTY BOREHOLES) FROM EXCEL FILE Sample Locations.XLS PROVIDED BY de maximis, INC. PONTE EQUITIES PROPERTY BOREHOLE LOCATIONS FROM SOIL BORING LOGS WORK ASSIGNMENT #0-183 FOR THE PONTE EQUITIES SITE, DATED JUNE 1, 2006, PROVIDED BY LOCKHEED MARTIN.

3.) MONITORING WELLS MW-1SM, MW-5SM, MW-9SM, MW-10SM, MW-12SM, MW-16SM MW-17SM AND BORING ESB-10SM FROM WELLS-050310.XLS, SURVEYED ON MAY 3, 2010 BY VARGO ASSOCIATES.

4.) ENVIRONMENTAL SOIL BORINGS ESB-2001 THROUGH ESB-2012 FROM CAD FILE BORINGS-082310.DWG, DATED AUGUST 23, 2010, PROVIDED BY VARGO ASSOCIATES.

CLAY THICKNESS RANGES

RANGE	COLOR
0.1' to 1.0'	
1.0' to 2.0'	
2.0' to 3.0'	
3.0' to 4.0'	
4.0' to 5.0'	
5.0' >	

30 0 30 60
SCALE FEET

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT

MARTIN AARON SUPERFUND SITE
CAMDEN, NEW JERSEY

TITLE

CLAY THICKNESS

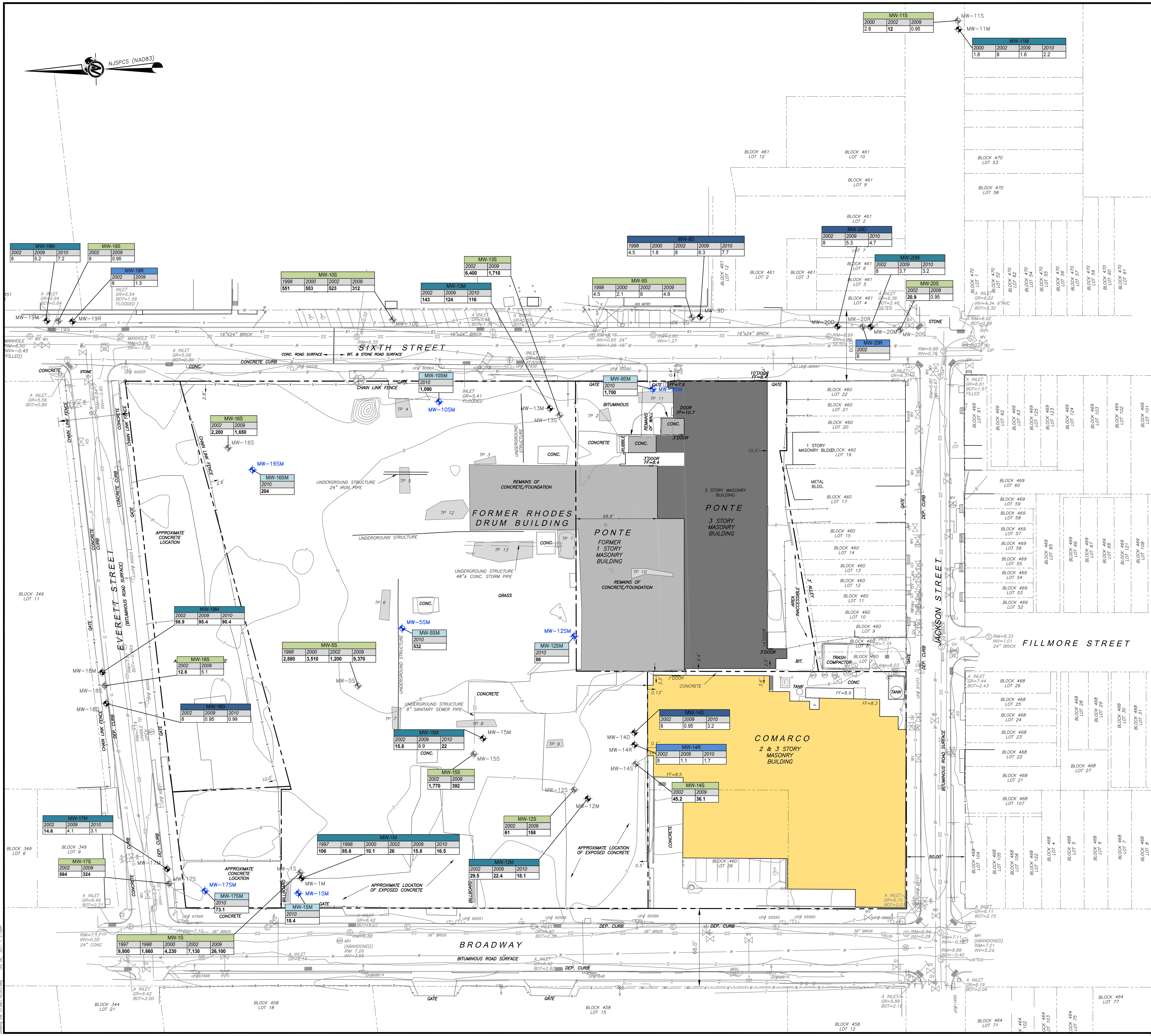
NJ Authorization #24GA28029100

Golder Associates
Mt. Laurel, New Jersey

PROJECT No.		073-86114
DESIGN	JLH	10/06/11
CADD	GLS	10/06/11
CHECK	MJB	10/06/11
REVIEW	RSW	10/06/11

FILE No. 07386144C007
SCALE AS SHOWN REV. 0

ATTACHMENT 1-4



LEGEND

- PROPERTY LINE
- ADJOINING PROPERTY LINE
- RAILROAD TRACK
- CHAIN LINK FENCE
- EXISTING CONTOUR
- SEWER/STORM SYSTEM
- COMMUNICATIONS LINE
- ELECTRIC LINE
- GAS LINE
- WATER LINE
- UTILITY POLE
- UTILITY POLE W/LIGHT
- GAS VALVE
- WATER VALVE
- FIRE HYDRANT
- WATER MANHOLE
- INLET
- SEWER/STORM MANHOLE
- CLEAN OUT
- MANHOLE (USE UNKNOWN)
- COMMUNICATIONS MANHOLE
- ELECTRIC MANHOLE
- VALVE-USE UNKNOWN
- MW-20M EXISTING MONITORING WELL
- MW-5SM REPLACEMENT SM-SERIES MONITORING WELL (SEE REFERENCE 3)
- MW-20S ABANDONED MONITORING WELL (S-SERIES WELLS DURING APRIL-MAY 2010 EVENT)

NOTES

1) RESULTS ARE IN MICROGRAMS PER LITER (μg/L).

2) VALUES LISTED ARE THE HIGHEST VALUE FOR A GIVEN YEAR (WITH YEARS ITALICIZED AND HIGHLIGHTED IN GRAY).

3.) WELL IDs ARE HIGHLIGHTED ACCORDING TO SERIES AND GENERALLY CORRESPOND WITH DEPTH (i.e., LIGHTER COLORS REPRESENT SHALLOWER WELLS AND DARKER COLORS REPRESENT DEEPER WELLS). S-SERIES = LIGHT GREEN, SM-SERIES = LIGHT AQUA, M-SERIES = DARK TEAL, R-SERIES = BLUE, D-SERIES = DARK BLUE.

4.) VALUES EQUAL TO OR GREATER THAN THE 10 μG/L MAXIMUM CONTAMINANT LEVEL (MCL) FOR ARSENIC ARE IN BOLD.

5.) DATA DERIVED FROM DDMS DATABASE.

REFERENCES

1.) MAP FROM DIGITAL CAD FILE MARTI-AARON-REV3.DWG ENTITLED "MAP OF SURVEY BLOCK 460, LOTS 1, 2, 3, 4, 26, & 29 CITY OF CAMDEN, CAMDEN COUNTY, NEW JERSEY DATED JULY 28, 2009, PREPARED BY VARGO ASSOCIATES.

2.) USEPA BOREHOLE LOCATIONS (OTHER THAN PONTE EQUITIES PROPERTY BOREHOLES) FROM EXCEL FILE Sample Locations.XLS PROVIDED BY de maximis, INC. PONTE EQUITIES PROPERTY BOREHOLE LOCATIONS FROM SOIL BORING LOGS WORK ASSIGNMENT #0-183 FOR THE PONTE EQUITIES SITE, DATED JUNE 1, 2006, PROVIDED BY LOCKHEED MARTIN.

3.) MONITORING WELLS MW-1SM, MW-5SM, MW-9SM, MW-10SM, MW-12SM, MW-16SM MW-17SM AND BORING ESB-10SM FROM WELLS-050310.XLS, SURVEYED ON MAY 3, 2010 BY VARGO ASSOCIATES.

30 0 30 60
SCALE FEET

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT

MARTIN AARON SUPERFUND SITE
CAMDEN, NEW JERSEY

TITLE

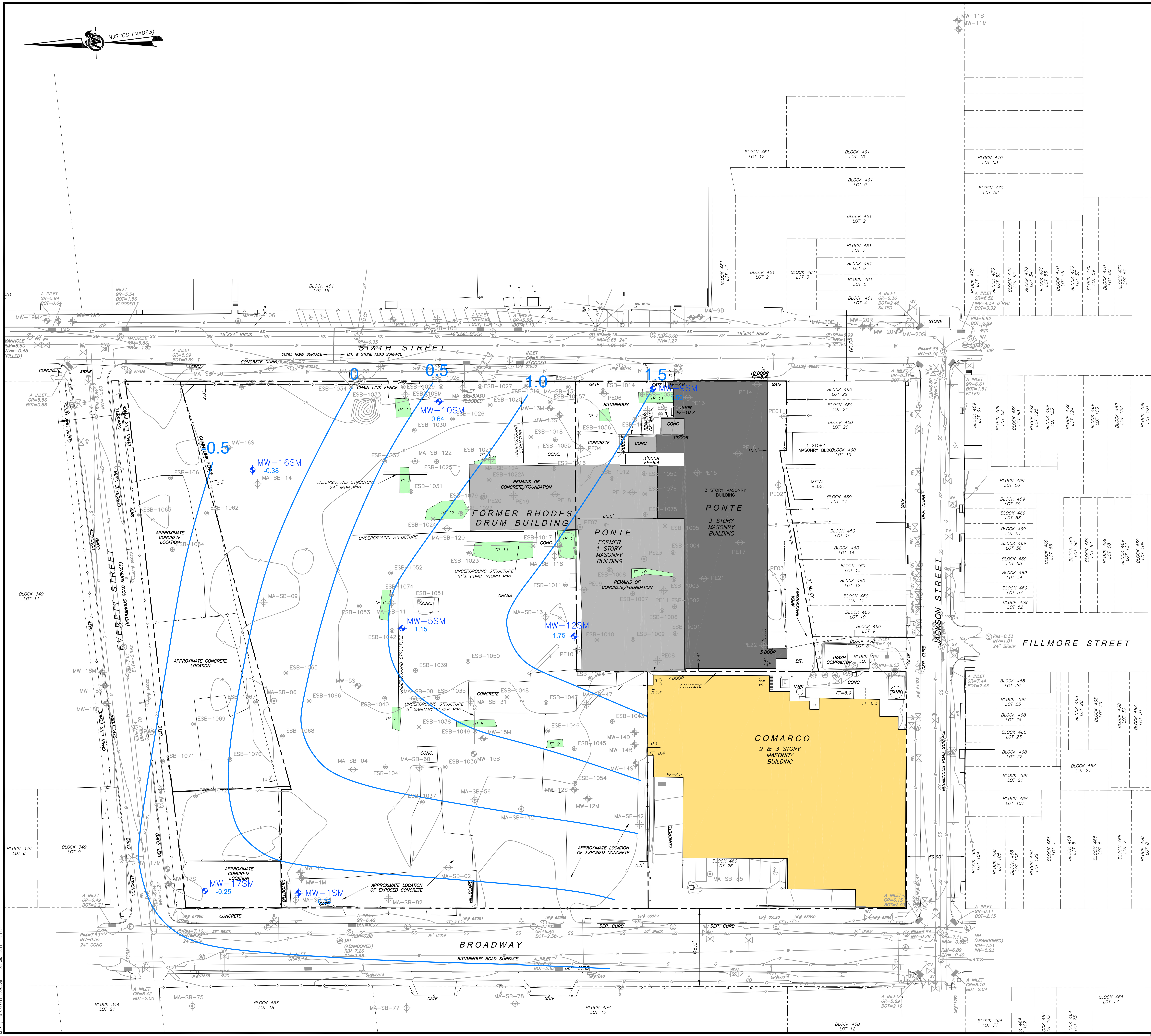
HISTORIC ARSENIC IN GROUNDWATER RESULTS

NJ Authorization #24GA28029100
Golder Associates
Mt. Laurel, New Jersey

PROJECT No.	073-86114	
DESIGN	LR	10/06/11
CADD	GLS	10/06/11
CHECK	MJB	10/06/11
REVIEW	RSW	10/06/11

FILE No. 07386114C003
SCALE AS SHOWN REV. 0

ATTACHMENT 1-5



LEGEND

PROPERTY LINE
ADJOINING PROPERTY LINE
RAILROAD TRACK
CHAIN LINK FENCE
EXISTING CONTOUR
SEWER/STORM SYSTEM
COMMUNICATIONS LINE
ELECTRIC LINE
GAS LINE
WATER LINE
UTILITY POLE
UTILITY POLE W/LIGHT
GAS VALVE
WATER VALVE
FIRE HYDRANT
WATER MANHOLE
INLET
SEWER/STORM MANHOLE
CLEAN OUT
MANHOLE (USE UNKNOWN)
COMMUNICATIONS MANHOLE
ELECTRIC MANHOLE
VALVE-USE UNKNOWN

MW-20M — EXISTING MONITORING WELL

MW-5SM — REPLACEMENT SM-SERIES MONITORING WELL (SEE REFERENCE 3)

MW-20S — ABANDONED MONITORING WELL (S-SERIES WELLS DURING APRIL-MAY 2010 EVENT)

ESB-10SM — ENVIRONMENTAL SOIL BORING (APRIL-MAY 2010 EVENT)

ENVIRONMENTAL SOIL BORING

PE17 — USEPA POST-ROD INVESTIGATION BORINGS

MA-SB-120 — USEPA RI BORINGS

1.5 — GROUNDWATER CONTOUR

1.50 — GROUNDWATER ELEVATION

REFERENCES

1.) MAP FROM DIGITAL CAD FILE MARTI-AARON-REV3.DWG ENTITLED "MAP OF SURVEY BLOCK 460, LOTS 1, 2, 3, 4, 26, & 29 CITY OF CAMDEN, CAMDEN COUNTY, NEW JERSEY DATED JULY 28, 2009, PREPARED BY VARGO ASSOCIATES.

2.) USEPA BOREHOLE LOCATIONS (OTHER THAN PONTE EQUITIES PROPERTY BOREHOLES) FROM EXCEL FILE Sample Locations.XLS PROVIDED BY de maximis, INC. PONTE EQUITIES PROPERTY BOREHOLE LOCATIONS FROM SOIL BORING LOGS WORK ASSIGNMENT #0-183 FOR THE PONTE EQUITIES SITE, DATED JUNE 1, 2006, PROVIDED BY LOCKHEED MARTIN.

3.) MONITORING WELLS MW-1SM, MW-5SM, MW-9SM, MW-10SM, MW-12SM, MW-16SM MW-17SM AND BORING ESB-10SM FROM WELLS-050310.XLS, SURVEYED ON MAY 3, 2010 BY VARGO ASSOCIATES.

SCALE 30 0 30 60 FEET

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT

MARTIN AARON SUPERFUND SITE
CAMDEN, NEW JERSEY

TITLE

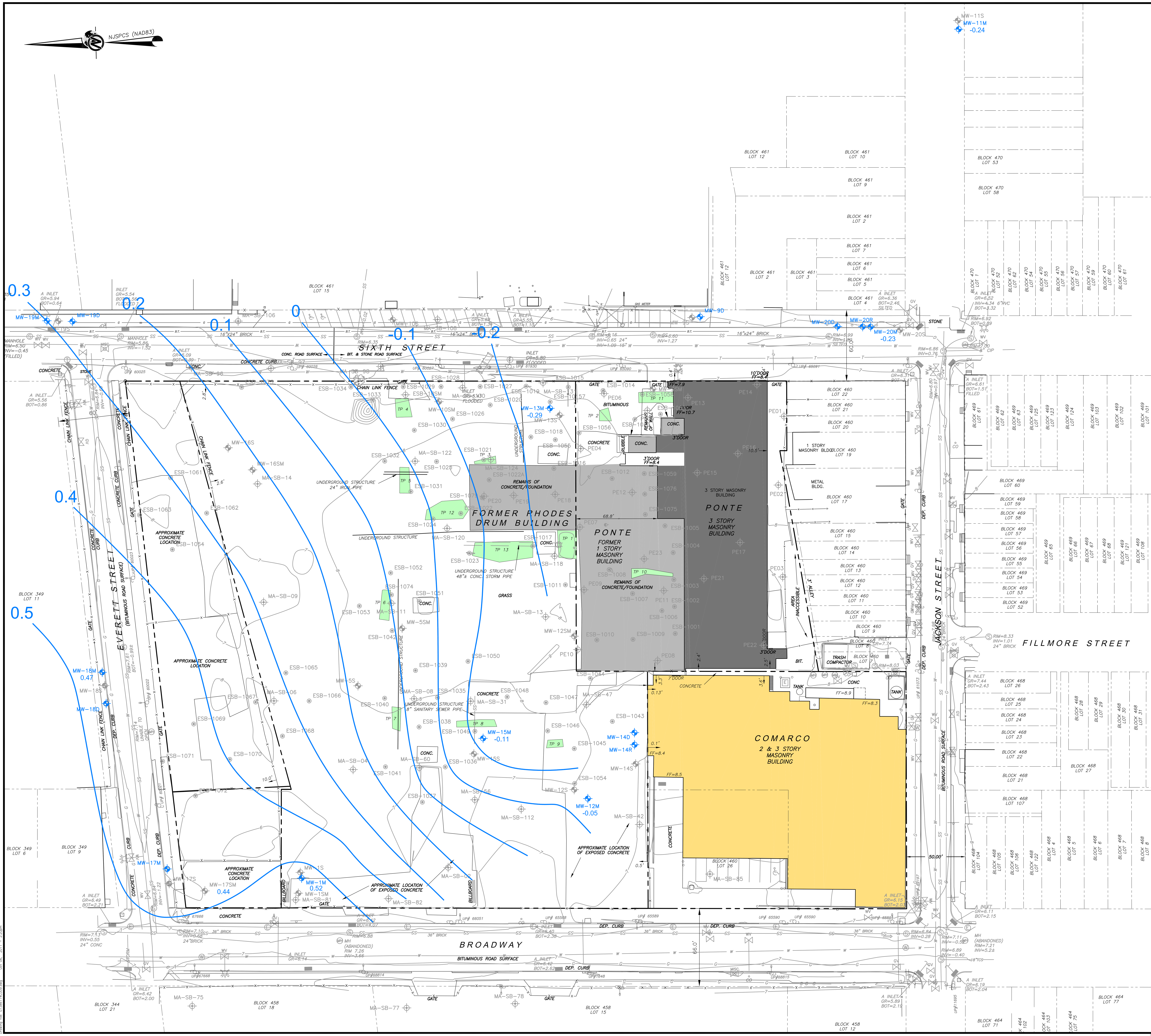
GROUNDWATER CONTOURS - SM-SERIES WELLS

Golder Associates
Mt. Laurel, New Jersey
NJ Authorization #24GA28029100

PROJECT No.	073-86114	
DESIGN	JLH	10/06/11
CADD	AM	10/06/11
CHECK	MJB	10/06/11
REVIEW	RSW	10/06/11

FILE No. 07386114C008
SCALE AS SHOWN REV. 0

ATTACHMENT 1-6



LEGEND

	PROPERTY LINE
	ADJOINING PROPERTY LINE
	RAILROAD TRACK
	CHAIN LINK FENCE
	EXISTING CONTOUR
	SEWER/STORM SYSTEM
	COMMUNICATIONS LINE
	ELECTRIC LINE
	GAS LINE
	WATER LINE
	UTILITY POLE
	UTILITY POLE W/LIGHT
	GAS VALVE
	WATER VALVE
	FIRE HYDRANT
	WATER MANHOLE
	INLET
	SEWER/STORM MANHOLE
	CLEAN OUT
	MANHOLE (USE UNKNOWN)
	COMMUNICATIONS MANHOLE
	ELECTRIC MANHOLE
	VALVE-USE UNKNOWN
MW-20M	EXISTING MONITORING WELL
MW-5SM	REPLACEMENT SM-SERIES MONITORING WELL (SEE REFERENCE 3)
MW-20S	ABANDONED MONITORING WELL (S-SERIES WELLS DURING APRIL-MAY 2010 EVENT)
ESB-105M	ENVIRONMENTAL SOIL BORING (APRIL-MAY 2010 EVENT)
	ENVIRONMENTAL SOIL BORING
PE17	USEPA POST-ROD INVESTIGATION BORINGS
MA-SB-120	USEPA RI BORINGS
-0.2	GROUNDWATER CONTOUR
-0.23	GROUNDWATER ELEVATION

REFERENCES

1.) MAP FROM DIGITAL CAD FILE MARTI-AARON-REV3.DWG ENTITLED "MAP OF SURVEY BLOCK 460, LOTS 1, 2, 3, 4, 26, & 29 CITY OF CAMDEN, CAMDEN COUNTY, NEW JERSEY DATED JULY 28, 2009, PREPARED BY VARGO ASSOCIATES.

2.) USEPA BOREHOLE LOCATIONS (OTHER THAN PONTE EQUITIES PROPERTY BOREHOLES) FROM EXCEL FILE Sample Locations.XLS PROVIDED BY de maximis, INC. PONTE EQUITIES PROPERTY BOREHOLE LOCATIONS FROM SOIL BORING LOGS WORK ASSIGNMENT #0-183 FOR THE PONTE EQUITIES SITE, DATED JUNE 1, 2006, PROVIDED BY LOCKHEED MARTIN.

3.) MONITORING WELLS MW-1SM, MW-5SM, MW-9SM, MW-10SM, MW-12SM, MW-16SM MW-17SM AND BORING ESB-10SM FROM WELLS-050310.XLS, SURVEYED ON MAY 3, 2010 BY VARGO ASSOCIATES.

SCALE 30 0 30 60 FEET

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT

MARTIN AARON SUPERFUND SITE
CAMDEN, NEW JERSEY

TITLE

GROUNDWATER CONTOURS - M-SERIES WELLS

Golder Associates
Mt. Laurel, New Jersey
NJ Authorization #24GA28029100

PROJECT No.		073-86114
DESIGN	JLH	10/06/11
CADD	AM	10/06/11
CHECK	MJB	10/06/11
REVIEW	RSW	10/06/11

FILE No. 07386114C009
SCALE AS SHOWN REV. 0

ATTACHMENT 1-7

ATTACHMENT 2

Attachment 2
Arsenic Concentrations in Groundwater
Martin Aaron Site
Camden, New Jersey

Well ID	Arsenic Concentration (ppb)[1] Year Sampled 1997	1998	2000	2002	2009	2010
S-Series						
MW-1S	9,800	1,660	4,230	7,130	26,100	-----
MW-5S	-----	2,880	3,510	1,200	9,370	-----
MW-9S	-----	4.5	2.1	8	4.8	-----
MW-10S	-----	551	553	523	312	-----
MW-11S	-----	-----	2.8	12	0.95	-----
MW-12S	-----	-----	-----	61	158	-----
MW-13S	-----	-----	-----	6,400	1,710	-----
MW-14S	-----	-----	-----	45.2	36.1	-----
MW-15S	-----	-----	-----	1,770	392	-----
MW-16S	-----	-----	-----	2,200	1,650	-----
MW-17S	-----	-----	-----	564	324	-----
MW-18S	-----	-----	-----	12.8	5.1	-----
MW-19S	-----	-----	-----	8	0.95	-----
MW-20S	-----	-----	-----	20.9	0.95	-----
SM-Series						
MW-1SM	-----	-----	-----	-----	-----	18.4
MW-5SM	-----	-----	-----	-----	-----	532
MW-9SM	-----	-----	-----	-----	-----	1,700
MW-10SM	-----	-----	-----	-----	-----	1,090
MW-12SM	-----	-----	-----	-----	-----	86
MW-16SM	-----	-----	-----	-----	-----	204
MW-17SM	-----	-----	-----	-----	-----	73.1
M-Series						
MW-1M	106	85.6	10.1	26	15.8	16.5
MW-11M	-----	-----	1.8	8	1.6	2.2
MW-12M	-----	-----	29.5	22.4	18.1	-----
MW-13M	-----	-----	-----	143	124	116
MW-15M	-----	-----	-----	15.8	8.9	22
MW-17M	-----	-----	-----	14.6	4.1	3.1
MW-18M	-----	-----	-----	98.9	95.4	90.4
MW-19M	-----	-----	-----	8	5.2	7.2
MW-20M	-----	-----	-----	8	3.7	3.2
R-Series						
MW-14R	-----	-----	-----	8	1.1	1.7
MW-19R	-----	-----	-----	8	1.3	-----
MW-20R	-----	-----	-----	8	-----	-----
D-Series						
MW-9D	-----	4.5	1.8	8	6.3	7.7
MW-14D	-----	-----	-----	2.4	0.95	3.2
MW-18D	-----	-----	-----	3.5	0.95	0.99
MW-20D	-----	-----	-----	8	5.3	4.7

Notes:
[1] Arsenic concentrations are listed as highest detect for a given year.
----- Denotes that data were not provided for that year.

Attachment 2
Arsenic Concentrations in Soil - Historic Fill
Martin Aaron Site
Camden, New Jersey

Sample Depth		Location ID	Boring ID	Arsenic Concentration (mg/Kg)[1]
Top	Bottom			
0	2	ESB-1040	ESB-1040-02	84.2
2	4	ESB-1006	ESB-1006-04	17.5
		ESB-1009	ESB-1009-04	22.5
		ESB-1010	ESB-1010-04	17.2
		ESB-1011	ESB-1011-04	78.2
		ESB-1013	ESB-1013-04	138
		ESB-1014	ESB-1014-04	**337**
		ESB-1015	ESB-1015-04	21.9
		ESB-1017	ESB-1017-04	14
		ESB-1018	ESB-1018-04	258
		ESB-1019	ESB-1019-04	16.8
		ESB-1020	ESB-1020-04	**975**
		ESB-1021	ESB-1021-04	164
		ESB-1022	ESB-1022-04	48.3
		ESB-1023	ESB-1023-04	149
		ESB-1024	ESB-1024-04	223
		ESB-1025	ESB-1025-04	164
		ESB-1026	ESB-1026-04	37.3
		ESB-1027	ESB-1027-04	47.2
		ESB-1028	ESB-1028-04	238
		ESB-1029	ESB-1029-04	27.7
		ESB-1031	ESB-1031-04	**709**
		ESB-1032	ESB-1032-04	92.7
		ESB-1033	ESB-1033-04	67.7
		ESB-1034	ESB-1034-04	84.1
		ESB-1035	ESB-1035-04	47.4
		ESB-1036	ESB-1036-04	14.6
		ESB-1037	ESB-1037-04	197
		ESB-1038	ESB-1038-04	298
		ESB-1039	ESB-1039-04	234
		ESB-1042	ESB-1042-04	-----
		ESB-1043	ESB-1043-04	-----
		ESB-1044	ESB-1044-04	-----
		ESB-1045	ESB-1045-04	-----
		ESB-1046	ESB-1046-04	-----
		ESB-1047	ESB-1047-04	-----
		ESB-1048	ESB-1048-04	-----
		ESB-1049	ESB-1049-04	-----
		ESB-1050	ESB-1050-04	-----
		ESB-1051	ESB-1051-04	-----
		ESB-1052	ESB-1052-04	-----
		ESB-1053	ESB-1053-04	-----
		ESB-1054	ESB-1054-04	-----
		ESB-1055	ESB-1055-04	51.6
		ESB-1056	ESB-1056-04	**325**
		ESB-1057	ESB-1057-04	47.5

Attachment 2
Arsenic Concentrations in Soil - Historic Fill
Martin Aaron Site
Camden, New Jersey

Sample Depth Top	Sample Depth Bottom	Location ID	Boring ID	Arsenic Concentration (mg/Kg)[1]
		ESB-1058	ESB-1058-04	25.1
2	4	ESB-1060	ESB-1060-04	26.5
		ESB-1061	ESB-1061-04	155
		ESB-1062	ESB-1062-04	83
		ESB-1063	ESB-1063-04	136
		ESB-1064	ESB-1064-04	14.2
		ESB-1065	ESB-1065-04	50.7
		ESB-1067	ESB-1067-04	188
		ESB-1068	ESB-1068-04	89.8
		ESB-1069	ESB-1069-04	14
		ESB-1070	ESB-1070-04	15.8
		ESB-1071	ESB-1071-04	18.4
		ESB-1072	ESB-1072-04	27.7
		ESB-1074	ESB-1074-04	-----
		ESB-1076	ESB-1076-04	9.61
5	7	ESB-1009	ESB-1009-07	101
5.5	8	ESB-1022	ESB-1022-07.5	17.5
6	8	ESB-1006	ESB-1006-08	122
		ESB-1008	ESB-1008-08	21.8
		ESB-1010	ESB-1010-08	31.1
		ESB-1011	ESB-1011-08	51.4
		ESB-1012	ESB-1012-08	96.2
		ESB-1013	ESB-1013-08	82.5
		ESB-1014	ESB-1014-08	73.1
		ESB-1016	ESB-1016-08	54.3
		ESB-1017	ESB-1017-08	80.5
		ESB-1019	ESB-1019-08	**519**
		ESB-1023	ESB-1023-08	174
		ESB-1027	ESB-1027-08	225
		ESB-1036	ESB-1036-08	34.2
		ESB-1042	ESB-1042-08	-----
		ESB-1043	ESB-1043-08	-----
		ESB-1044	ESB-1044-08	-----
		ESB-1045	ESB-1045-08	-----
		ESB-1046	ESB-1046-08	-----
		ESB-1047	ESB-1047-08	-----
		ESB-1048	ESB-1048-08	-----
		ESB-1049	ESB-1049-08	-----
		ESB-1050	ESB-1050-08	-----
		ESB-1051	ESB-1051-08	-----
		ESB-1052	ESB-1052-08	-----
		ESB-1053	ESB-1053-08	-----
		ESB-1054	ESB-1054-08	-----
		ESB-1055	ESB-1055-08	52.8
		ESB-1057	ESB-1057-08	76
		ESB-1059	ESB-1059-08	26.8

Attachment 2
Arsenic Concentrations in Soil - Historic Fill
Martin Aaron Site
Camden, New Jersey

Sample Depth		Location ID	Boring ID	Arsenic Concentration (mg/Kg)[1]
Top	Bottom			
		ESB-1061	ESB-1061-08	13.3
		ESB-1062	ESB-1062-08	267
		ESB-1063	ESB-1063-08	9.98
		ESB-1064	ESB-1064-08	55.2
		ESB-1067	ESB-1067-08	23.1
		ESB-1069	ESB-1069-08	25.7
6	8	ESB-1070	ESB-1070-08	27.6
		ESB-1071	ESB-1071-08	14.8
		ESB-1074	ESB-1074-08	-----
		ESB-1076	ESB-1076-08	120
8	10	ESB-1044	ESB-1044-10	-----
8.5	10.5	ESB-1010	ESB-1010-10.5	18.1
		ESB-1054	ESB-1054-10.5	-----
9	11	ESB-1011	ESB-1011-11	240
9.5	11.5	ESB-1045	ESB-1045-11.5	-----
10	12	ESB-1006	ESB-1006-12	12.3
		ESB-1023	ESB-1023-12	**429**
		ESB-1040	ESB-1040-12	190
		ESB-1074	ESB-1074-12	-----

Notes:
[1] **Bolded** concentrations represent exceedances of the 300 ppm (mg/Kg) PRG for Arsenic in soil.

Attachment 2
Arsenic Concentrations in Soil - White Material
Martin Aaron Site
Camden, New Jersey

Sample Depth		Location ID	Boring ID	Arsenic Concentration (mg/Kg)[1]
Top	Bottom			
2	4	ESB-1030	ESB-1030-04	**2350**
		ESB-1041	ESB-1041-04	**1360**
4	6	ESB-1030	ESB-1030-06	**6250**
		ESB-1037	ESB-1037-06	**8450**
5	7	ESB-1029	ESB-1029-07	**6200**
6	8	ESB-1021	ESB-1021-08	**348**
		ESB-1022A	ESB-1022A-08	**6380**
		ESB-1025	ESB-1025-08	**4450**
		ESB-1031	ESB-1031-08	**1060**
		ESB-1032	ESB-1032-08	**1140**
		ESB-1035	ESB-1035-08	**1010**
		ESB-1038	ESB-1038-08	**19800**
		ESB-1039	ESB-1039-08	**698**
		ESB-1040	ESB-1040-08	**360**
		ESB-1056	ESB-1056-08	**1610**
		ESB-1066	ESB-1066-08	**5140**
		ESB-1079	ESB-1079-08	**11300**
8	9	ESB-1031	ESB-1031-09	**6570**
8	10	ESB-1038	ESB-1038-10	**560**
		ESB-1039	ESB-1039-10	**327**
		ESB-1053	ESB-1053-10	-----
9	11	ESB-1052	ESB-1052-11	-----
10	12	ESB-1059	ESB-1059-12	**1190**

Notes:
[1] **Bolded** concentrations represent exceedances of the 300 ppm (mg/Kg) PRG for Arsenic in soil.

Attachment 2
Arsenic Concentrations in Soil - MMC
Martin Aaron Site
Camden, New Jersey

Sample Depth Top	Sample Depth Bottom	Location ID	Boring ID	Arsenic Concentration (mg/Kg)[1]
2	4	ESB-1066	ESB-1066-04	39.1
6	8	ESB-1015	ESB-1015-08	**3680**
		ESB-1018	ESB-1018-08	**490**
		ESB-1020	ESB-1020-08	**3540**
		ESB-1024	ESB-1024-08	**418**
		ESB-1026	ESB-1026-08	**3000**
		ESB-1033	ESB-1033-08	**14900**
		ESB-1034	ESB-1034-08	**15500**
		ESB-1041	ESB-1041-08	**1840**
		ESB-1058	ESB-1058-08	**1600**
		ESB-1060	ESB-1060-08	**16300**
		ESB-1065	ESB-1065-08	**21500**
		ESB-1068	ESB-1068-08	**1500**
		ESB-1072	ESB-1072-08	**704**
7.5	9.5	ESB-1020	ESB-1020-9.5	**1040**
		ESB-1026	ESB-1026-9.5	**9750**
		ESB-1046	ESB-1046-09.5	-----
8	10	ESB-1014	ESB-1014-10	**2800**
		ESB-1015	ESB-1015-10	**10800**
		ESB-1025	ESB-1025-10	**5890**
		ESB-1027	ESB-1027-10	**4970**
		ESB-1032	ESB-1032-10	**7180**
		ESB-1033	ESB-1033-10	**11900**
		ESB-1048	ESB-1048-10	-----
		ESB-1049	ESB-1049-10	-----
		ESB-1050	ESB-1050-10	-----
		ESB-1055	ESB-1055-10	**19600**
		ESB-1056	ESB-1056-10	**13400**
		ESB-1065	ESB-1065-10	**3910**
		ESB-1066	ESB-1066-10	**6670**
		ESB-1072	ESB-1072-10	4.86
		ESB-1079	ESB-1079-10	**879**
8.5	10.5	ESB-1036	ESB-1036-10.5	34.8
9	11	ESB-1019	ESB-1019-11	**9050**
		ESB-1041	ESB-1041-11	65.3
		ESB-1042	ESB-1042-11	-----
		ESB-1047	ESB-1047-11	-----
		ESB-1060	ESB-1060-11	21
		ESB-1069	ESB-1069-11	2.52
9.5	11.5	ESB-1017	ESB-1017-11.5	**1160**
		ESB-1061	ESB-1061-11.5	**975**
10	12	ESB-1022A	ESB-1022A-12	**8990**
		ESB-1024	ESB-1024-12	**684**
		ESB-1035	ESB-1035-12	**2050**
		ESB-1051	ESB-1051-12	-----
		ESB-1057	ESB-1057-12	**12600**

Attachment 2
Arsenic Concentrations in Soil - MMC
Martin Aaron Site
Camden, New Jersey

Sample Depth Top	Sample Depth Bottom	Location ID	Boring ID	Arsenic Concentration (mg/Kg)[1]
		ESB-1062	ESB-1062-12	39.9
10	12	ESB-1063	ESB-1063-12	111
		ESB-1064	ESB-1064-12	**5210**
		ESB-1067	ESB-1067-12	**430**
		ESB-1070	ESB-1070-12	**610**
		ESB-1071	ESB-1071-12	27.9
		ESB-1076	ESB-1076-12	79.9
11	13	ESB-1069	ESB-1069-13	4.56
12	13	ESB-1051	ESB-1051-13	-----
		ESB-1067	ESB-1067-13	17.4
		ESB-1070	ESB-1070-13	31.5
		ESB-1074	ESB-1074-13	-----
12	14	ESB-1035	ESB-1035-14	71.7
		ESB-1061	ESB-1061-14	8.12
		ESB-1062	ESB-1062-14	26.3
		ESB-1063	ESB-1063-14	8.42
		ESB-1064	ESB-1064-14	7.2
		ESB-1071	ESB-1071-14	6.39
		ESB-1072	ESB-1072-14	5.37

Notes:
[1] **Bolded** concentrations represent exceedances of the 300 ppm (mg/Kg) PRG for Arsenic in soil.

Attachment 2
Arsenic Concentrations in Soil - Sand
Martin Aaron Site
Camden, New Jersey

Sample Depth		Location ID	Boring ID	Arsenic Concentration (mg/Kg)[1]
Top	Bottom			
10	12	ESB-1043	ESB-1043-12	-----
12	14	ESB-1059	ESB-1059-14	15.7
13	15	ESB-1016	ESB-1016-15	5.62
		ESB-1022A	ESB-1022A-15	5
14	16	ESB-1006	ESB-1006-16	6.72
		ESB-1010	ESB-1010-16	4.13
		ESB-1012	ESB-1012-16	213
		ESB-1024	ESB-1024-16	49
		ESB-1076	ESB-1076-16	93.8

Notes:
[1] **Bolded** concentrations represent exceedances of the 300 ppm (mg/Kg) PRG for Arsenic in soil.

Attachment 2
Arsenic Stratification Soil Chemistry Results
Martin Aaron Site
Camden, New Jersey

Depth (ft bgs)	Location ID	Boring ID	Arsenic Concentration (mg/Kg)[1]
7	ESB-2001	ESB-2001-7 W	**1,120**
7.5	ESB-2001	ESB-2001-7.5 CL	**34,400**
8	ESB-2001	ESB-2001-8 CL	**11,200**
8.5	ESB-2001	ESB-2001-8.5 CL	**8,770**
9	ESB-2001	ESB-2001-9 PT	249
9.5	ESB-2001	ESB-2001-9.5 PT	203
10	ESB-2001	ESB-2001-10 PT	206
11	ESB-2001	ESB-2001-11 S	18.7
9	ESB-2002	ESB-2002-9 CL	**13,600**
11	ESB-2002	ESB-2002-11 CL	**9,880**
11.5	ESB-2002	ESB-2002-11.5 CL	**12,500**
12	ESB-2002	ESB-2002-12 PT	80.7
12.5	ESB-2002	ESB-2002-12.5 PT	**371**
13	ESB-2002	ESB-2002-13 PT	35.9
14	ESB-2002	ESB-2002-14 S	5.92
8	ESB-2003	ESB-2003-8 W	24.2
10.5	ESB-2003	ESB-2003-10.5 CL	196
11	ESB-2003	ESB-2003-11 PT	106
11.5	ESB-2003	ESB-2003-11.5 PT	144
12	ESB-2003	ESB-2003-12 PT	129
13	ESB-2003	ESB-2003-13 S	6.25
5	ESB-2004	ESB-2004-5W	**6,150**
11.5	ESB-2004	ESB-2004-11.5 CL	**10,600**
12	ESB-2004	ESB-2004-12 CL	**10,200**
12.5	ESB-2004	ESB-2004-12.5 PT	**903**
13	ESB-2004	ESB-2004-13PT	133
13.5	ESB-2004	ESB-2004-13.5 PT	90.4
14.5	ESB-2004	ESB-2004-14.5 S	11.5
8	ESB-2005	ESB-2005-8 W	**6,440**
8.5	ESB-2005	ESB-2005-8.5 CL	**10,700**
9	ESB-2005	ESB-2005-9 CL	**9,300**
9.5	ESB-2005	ESB-2005-9.5 CL	**10,200**
10	ESB-2005	ESB-2005-10 CL	**14,800**
10.5	ESB-2005	ESB-2005-10.5 CL	**450**
11	ESB-2005	ESB-2005-11 CL	**11,000**
11.5	ESB-2005	ESB-2005-11.5 CL	**321**
12	ESB-2005	ESB-2005-12 CL	260
12.5	ESB-2005	ESB-2005-12.5 CL	**721**
13	ESB-2005	ESB-2005-13 PT	107
13.5	ESB-2005	ESB-2005-13.5 PT	25.1

Notes:
[1] **Red bolded font** with pink highlighting indicates concentrations that exceed the 300 mg/Kg for arsenic in soil.

Attachment 2
Arsenic Stratification Soil Chemistry Results
Martin Aaron Site
Camden, New Jersey

Depth (ft bgs)	Location ID	Boring ID	Arsenic Concentration (mg/Kg)[1]
14	ESB-2005	ESB-2005-14 PT	25.3
14.5	ESB-2005	ESB-2005-14.5 PT	14.9
15	ESB-2005	ESB-2005-15 S	1.4
12.5	ESB-2006	ESB-2006-12.5 W	**1,140**
13.5	ESB-2006	ESB-2006-13.5 CL	89.5
14	ESB-2006	ESB-2006-14 CL	29.4
14.5	ESB-2006	ESB-2006-14.5 PT	49.9
15	ESB-2006	ESB-2006-15 PT	45.3
16	ESB-2006	ESB-2006-16 S	5.99
9.5	ESB-2007	ESB-2007-9.5 W	**1,450**
11.5	ESB-2007	ESB-2007-11.5 CL	282
12	ESB-2007	ESB-2007-12 CL	**854**
12.5	ESB-2007	ESB-2007-12.5	64.9
13	ESB-2007	ESB-2007-13 CL	**398**
13.5	ESB-2007	ESB-2007-13.5 CL	**2,000**
14	ESB-2007	ESB-2007-14 CL	86.1
14.5	ESB-2007	ESB-2007-14.5 CL	147
15	ESB-2007	ESB-2007-15 CL	198
16	ESB-2007	ESB-2007-16S	8.25
10	ESB-2008	ESB-2008-10W	**2,050**
12.5	ESB-2008	ESB-2008-12.5 CL	110
13	ESB-2008	ESB-2008-13 CL	18.3
13.5	ESB-2008	ESB-2008-13.5 CL	12.6
14	ESB-2008	ESB-2008-14 CL	14.3
14.5	ESB-2008	ESB-2008-14.5 CL	18.8
15	ESB-2008	ESB-2008-15 PT	14.5
15.5	ESB-2008	ESB-2008-15.5 PT	14.6
16	ESB-2008	ESB-2008-16 PT	11.4
17	ESB-2008	ESB-2008-17S	1.81
9.5	ESB-2009	ESB-2009-9.5 W	**2,810**
12.5	ESB-2009	ESB-2009-12.5CL	71.8
13	ESB-2009	ESB-2009-13 CL	88.3
13.5	ESB-2009	ESB-2009-13.5 CL	8.64
14	ESB-2009	ESB-2009-14 CL	83.6
14.5	ESB-2009	ESB-2009-14.5 CL	17.8
15	ESB-2009	ESB-2009-15 PT	15.2
15.5	ESB-2009	ESB-2009-15.5 PT	15.9
16	ESB-2009	ESB-2009-16 PT	6.99
17	ESB-2009	ESB-2009-17 S	9.89

Notes:
[1] **Red bolded font** with pink highlighting indicates concentrations that exceed the 300 mg/Kg for arsenic in soil.

Attachment 2
Geochemical Parameter - Total Sulfur
Martin Aaron Site
Camden, New Jersey

Sample ID	Total Sulfur (%)[1]	Laboratory Qualifier	Reporting Limit
ESB-2001-8-CL 6059835	<0.5	U	0.5
ESB-2001-10-PT 6059836	<0.5	U	0.5
ESB-2002-9-CL 6059837	0.5399		0.5
ESB-2002-12-PT 6059838	<0.5	U	0.5
ESB-2003-12-PT 6059839	<0.5	U	0.5
ESB-2003-10.5-CT 6059840	<0.5	U	0.5
ESB-2004-11.5-CL 6059841	<0.5	U	0.5
ESB-2004-13-PT 6059842	<0.5	U	0.5
ESB-2005-10-CL 6059843	<0.5	U	0.5
ESB-2005-14-PT 6059844	<0.5	U	0.5
ESB-2006-14-CL 6059846	<0.5	U	0.5
ESB-2006-15-PT 6059845	<0.5	U	0.5
ESB-2007-15-CL 6059847	<0.5	U	0.5
ESB-2008-14-CL 6059849	<0.5	U	0.5
ESB-2008-16-PT 6059848	<0.5	U	0.5
ESB-2009-14-CL 6059851[2]	<0.5	U	0.5
ESB-2009-16-PT 6059850	<0.5	U	0.5

Notes:

[1] Samples collected in August 2010.

[2] QA/QC sample (i.e., field duplicate; FD) collected along with primary sample. Results, laboratory qualifiers, and reporting limits are identical for primary and FD.

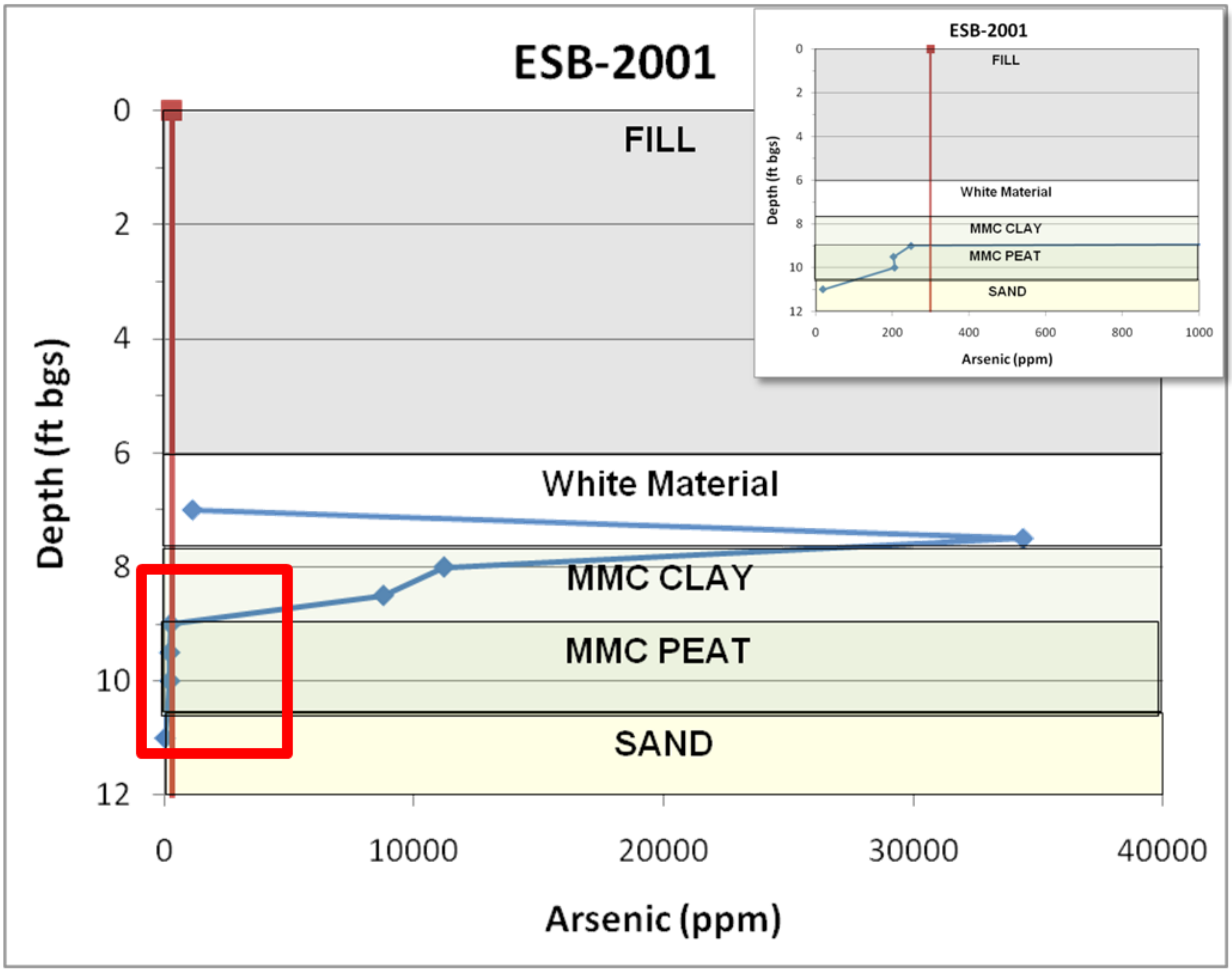
Attachment 2
Geochemical Parameters - pH, TOC, Total Iron
Martin Aaron Site
Camden, New Jersey

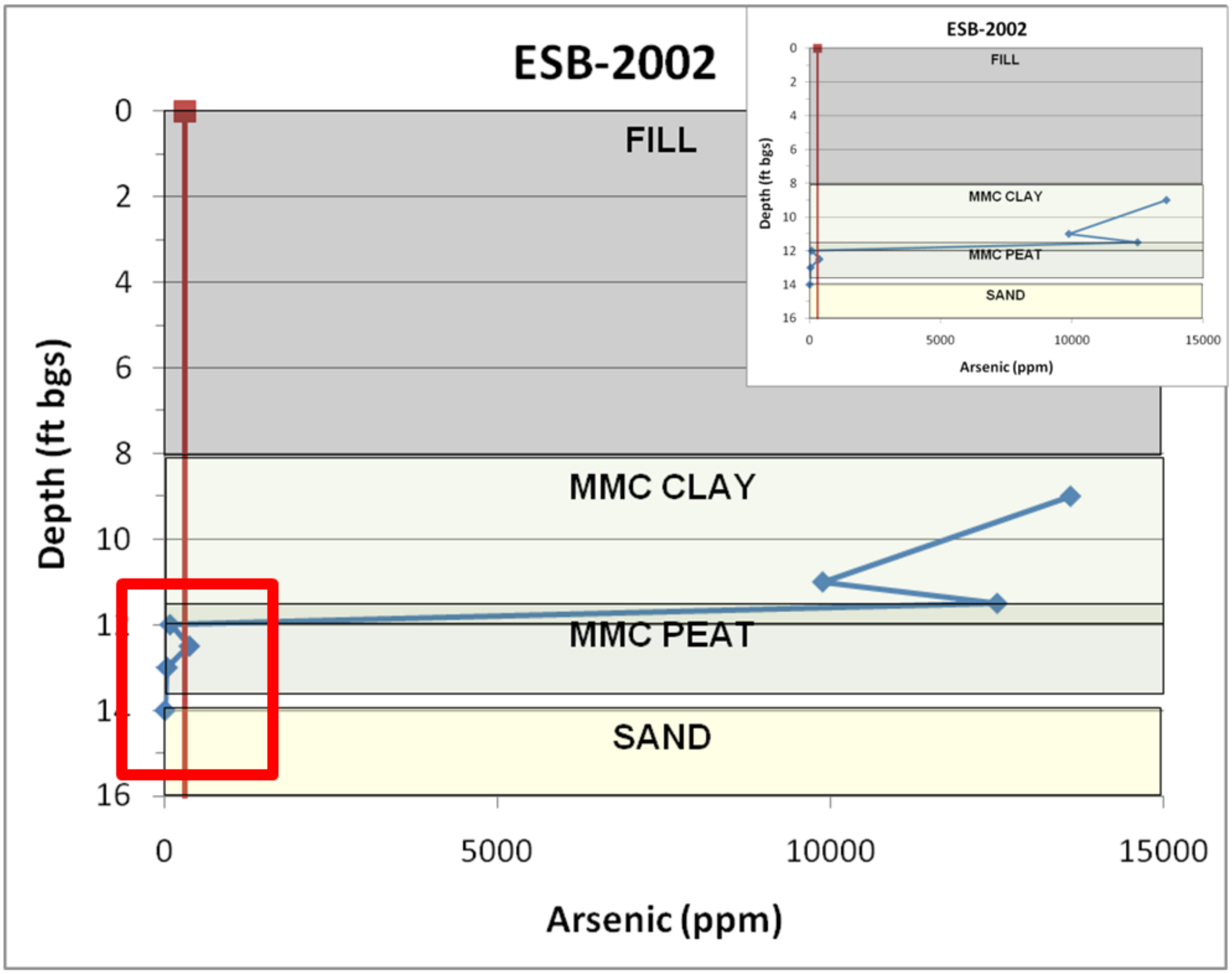
Sample Depth		Location ID	Sample ID	pH (std)	TOC (mg/Kg)	Total Iron Concentration (mg/Kg)
Top	Bottom					
4	5	ESB-2004	ESB-2004-5-W	-----	-----	5,960
6	7	ESB-2001	ESB-2001-7-W	-----	-----	19,400
7.5	8	ESB-2001	ESB-2001-8-CL-1140	11.5	117,000	9,700
8.5	9	ESB-2002	ESB-2002-9-CL	9.85	107,000	9,120
8.5	9.5	ESB-2007	ESB-2007-9.5-W	-----	-----	8,080
		ESB-2009	ESB-2009-9.5-W	-----	-----	16,300
9.5	10	ESB-2001	ESB-2001-10-PT-1145	9.16	121,000	22,100
		ESB-2005	ESB-2005-10-CL	12.3	86,800	8,870
10	10.5	ESB-2003	ESB-2003-10.5-CL-0905	8.51	81,300	23,900
11	11.5	ESB-2004	ESB-2004-11.5-CL-0952	9.38	127,000	8,570
11.5	12	ESB-2002	ESB-2002-12-PT	9.1	117,000	26,000
		ESB-2003	ESB-2003-12-PT	8.3	73,900	10,200
11.5	12.5	ESB-2006	ESB-2006-12.5-W	-----	-----	14,600
12.5	13	ESB-2004	ESB-2004-13-PT-0958	8.7	89,100	18,500
13.5	14	ESB-2005	ESB-2005-14-PT	8.87	130,000	28,600
		ESB-2006	ESB-2006-14-CL-1420	8.68	33,500	27,700
		ESB-2008	ESB-2008-14-CL-1053	8.52	55,000	30,000
		ESB-2009	ESB-2009-14-CL	8.41	13,700	34,400
14.5	15	ESB-2006	ESB-2006-15-PT	8.07	49,800	22,800
		ESB-2007	ESB-2007-15-CL-0854	8.44	36,600	30,900
15.5	16	ESB-2008	ESB-2008-16-PT	6.86	77,400	25,000
		ESB-2009	ESB-2009-16-PT	7.63	28,600	23,900

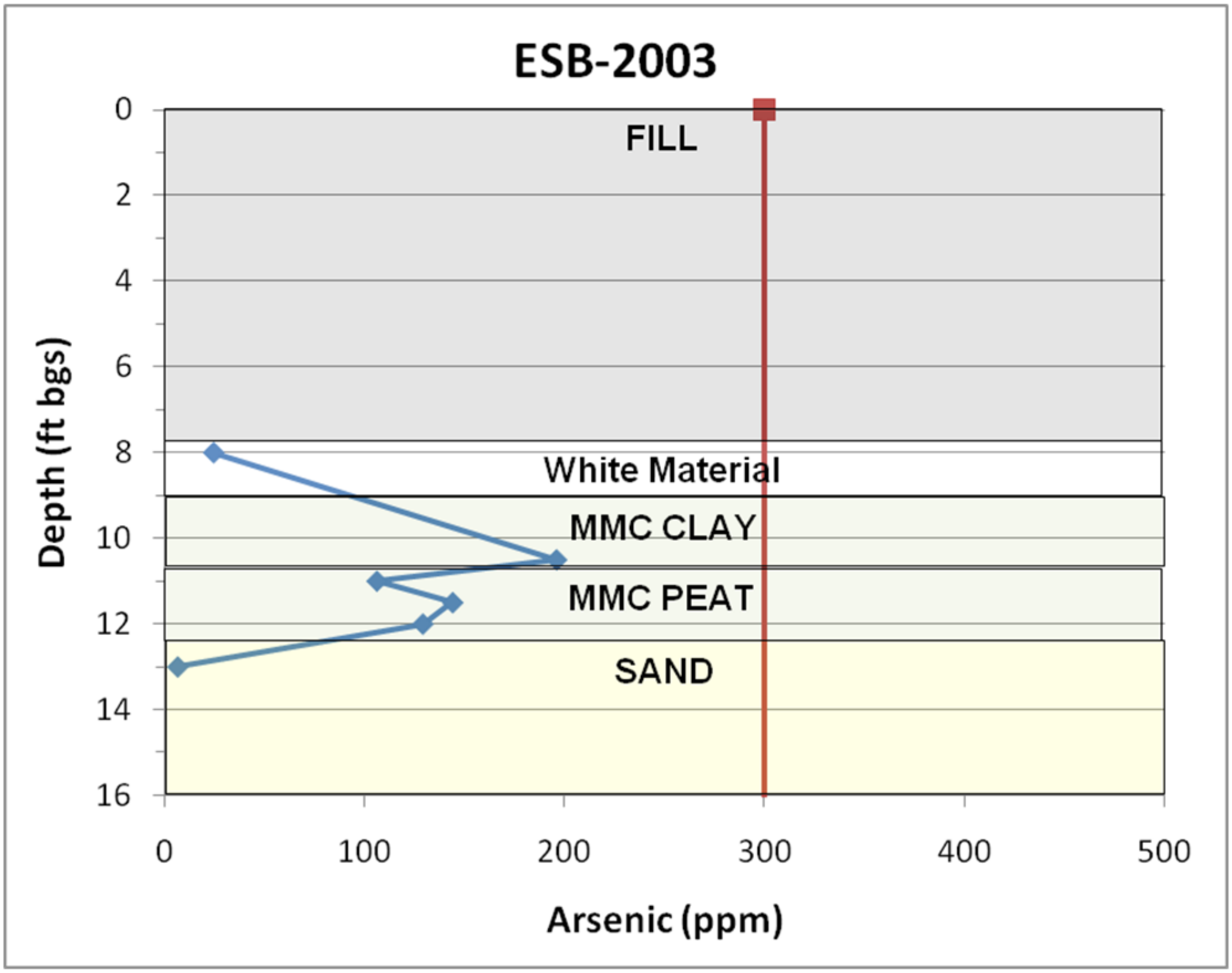
Notes:
All samples collected in August 2010.
TOC = Total organic carbon.

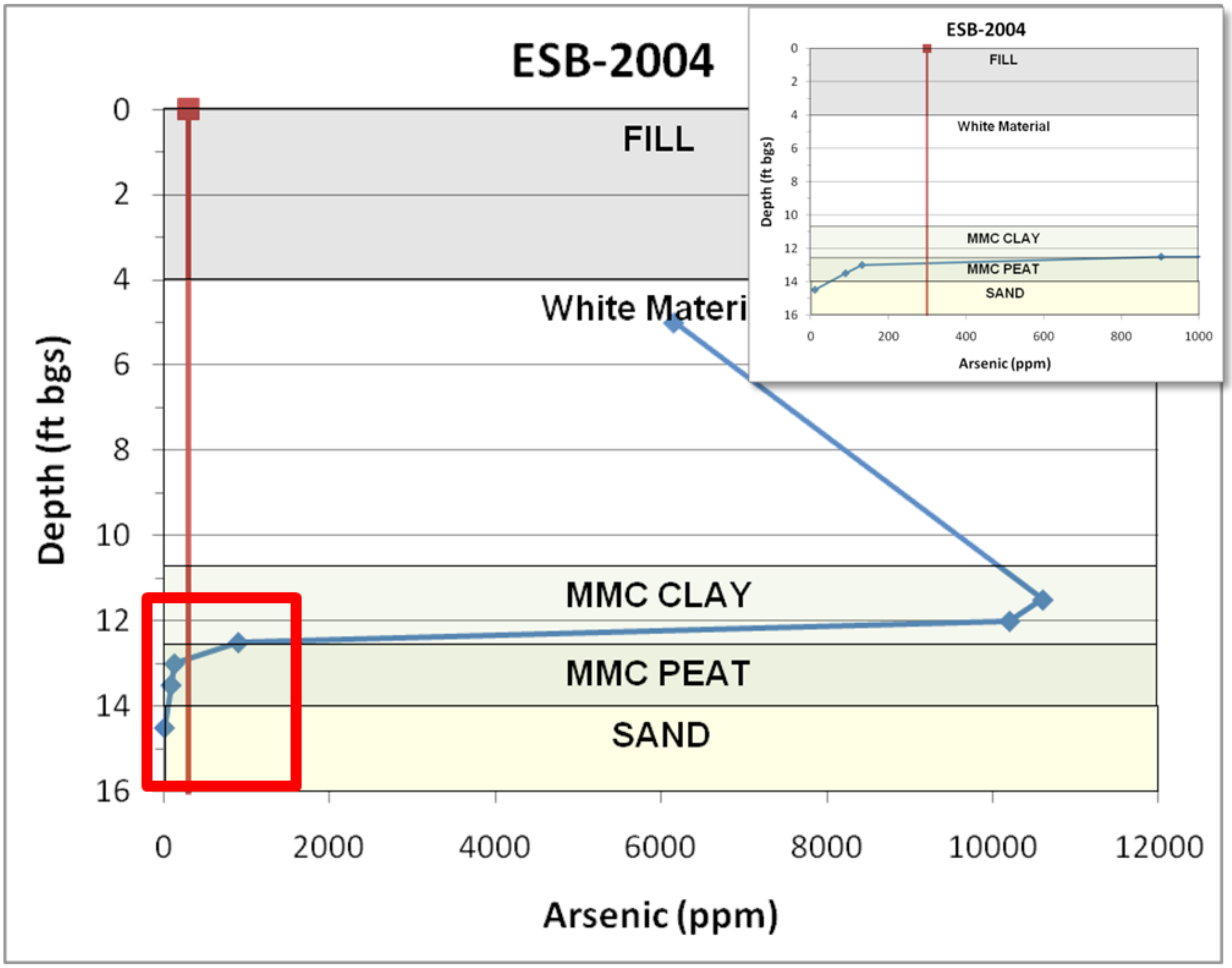
ATTACHMENT 3

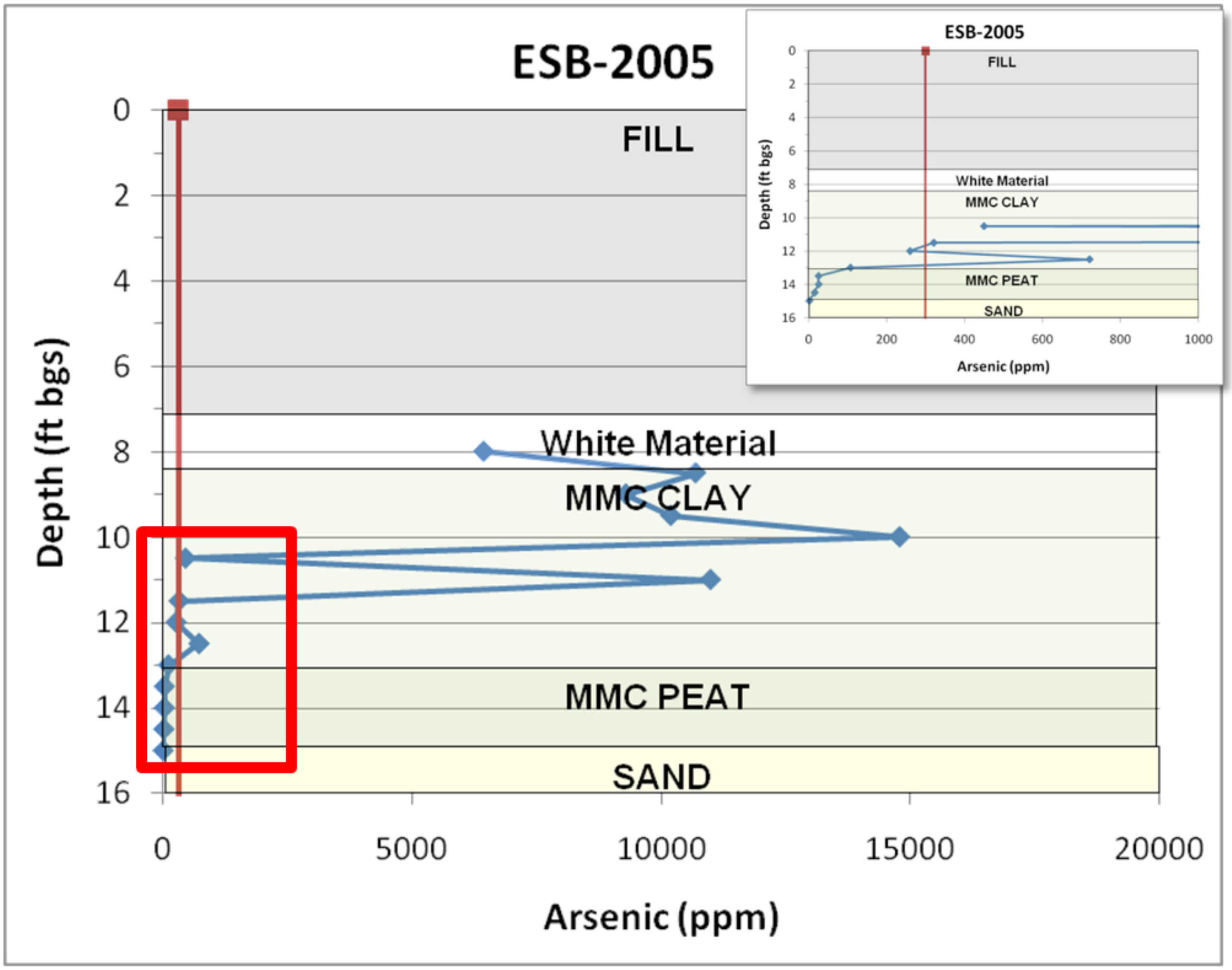
Depth versus arsenic concentration graphs, which illustrate stratification at depth for individual soil borings. A vertical red line illustrates the 300 mg/kg PRG. Inset figures (top right) are included to show higher resolution below 300 mg/kg where applicable.

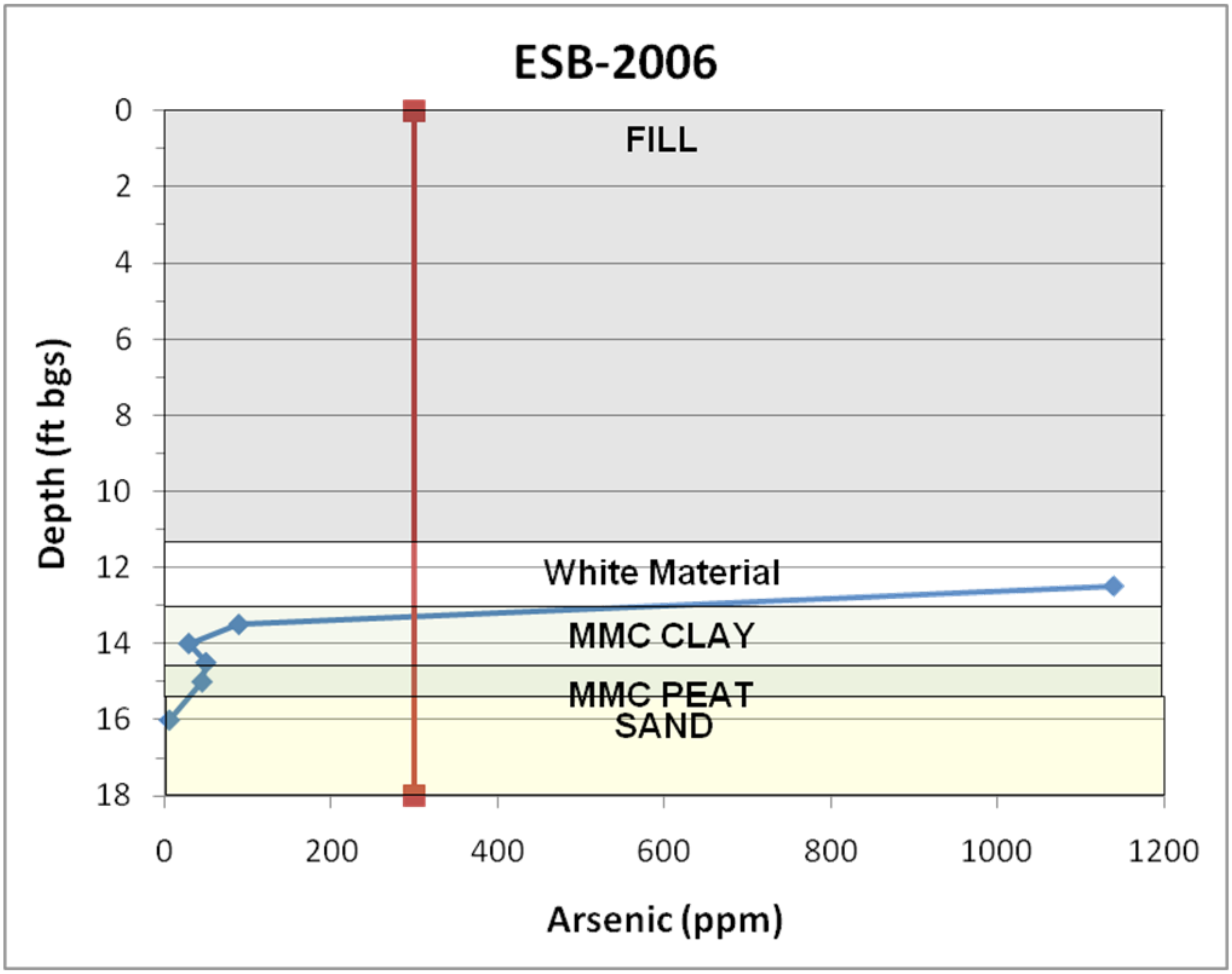


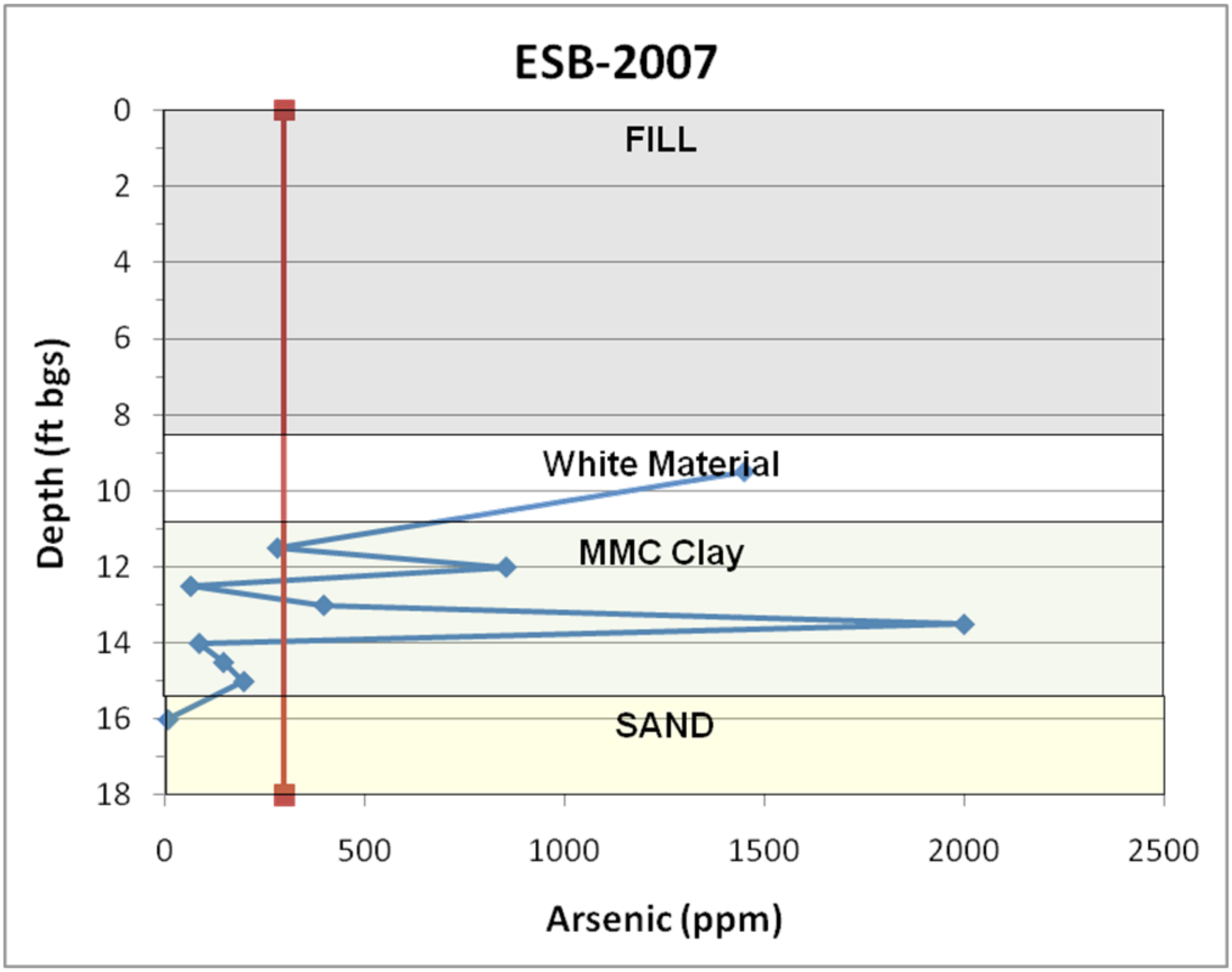

ESB-2002
FILL
MMC CLAY
MMC PEAT
SAND
Depth (ft bgs)
Arsenic (ppm)
0
2
4
6
8
10
16
0
5000
10000
15000

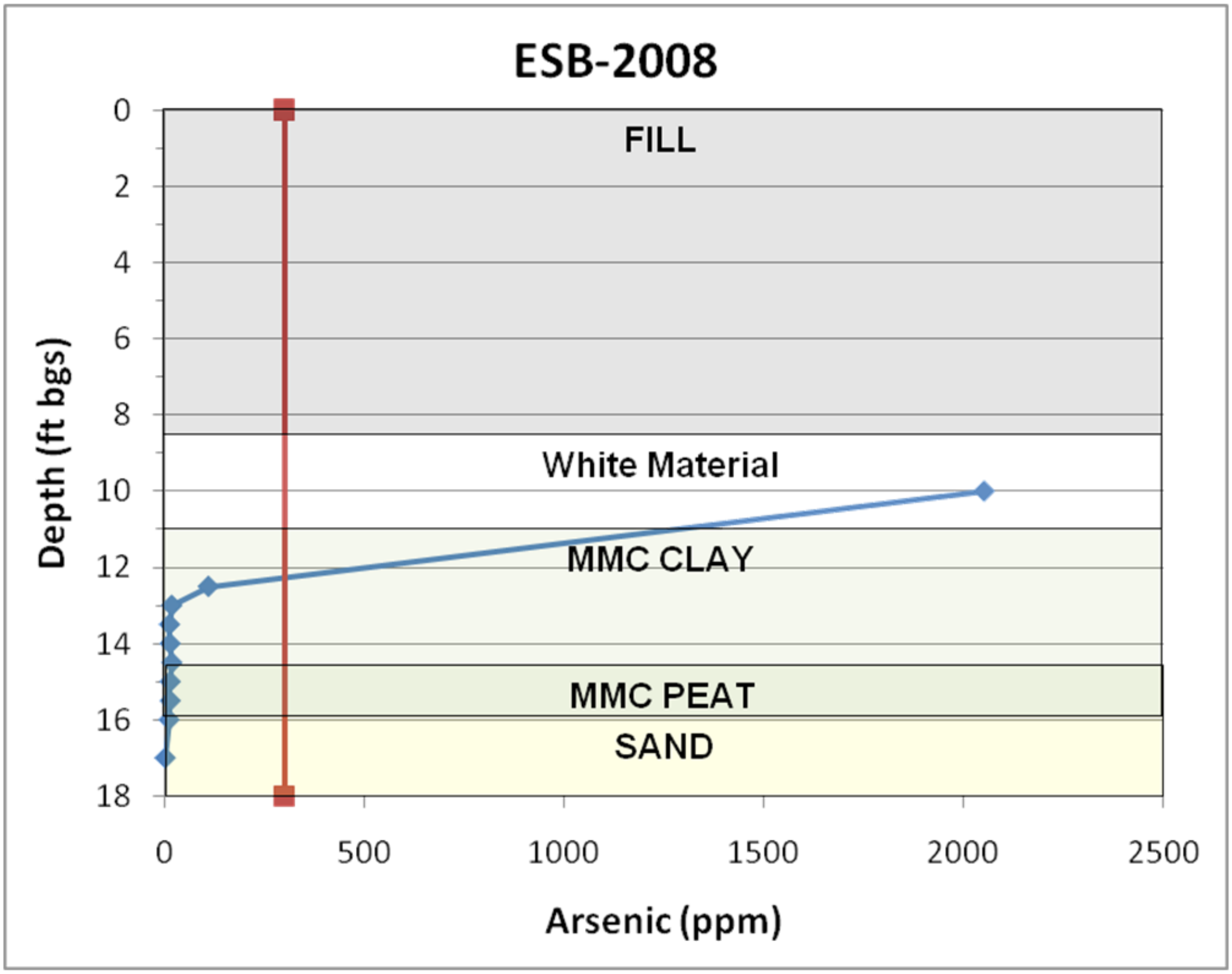

ESB-2003
FILL
White Material
MMC CLAY
MMC PEAT
SAND
Depth (ft bgs)
0
2
4
6
8
10
12
14
16
0
100
200
300
400
500
Arsenic (ppm)

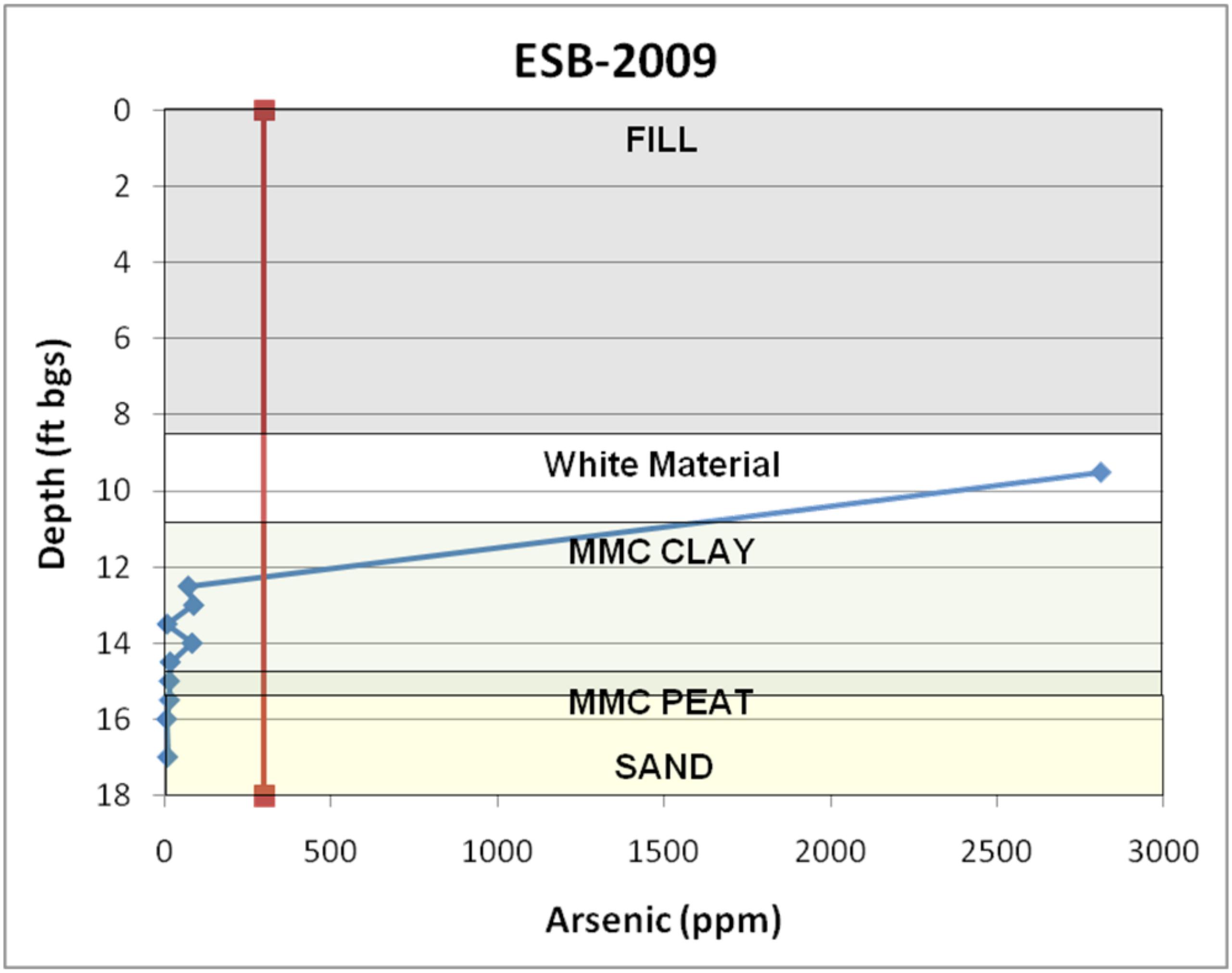

ESB-2004
FILL
White Materi
MMC CLAY
MMC PEAT
SAND
Depth (ft bgs)
Arsenic (ppm)
0
2
4
6
8
10
12
14
16
0
2000
4000
6000
8000
10000
12000
ESB-2004
FILL
White Material
MMC CLAY
MMC PEAT
SAND
Depth (ft bgs)
Arsenic (ppm)
0
200
400
600
800
1000


ESB-2005
FILL
White Material
MMC CLAY
MMC PEAT
SAND
Depth (ft bgs)
Arsenic (ppm)
0
2
4
6
8
10
12
14
16
0
5000
10000
15000
20000
ESB-2005
FILL
White Material
MMC CLAY
MMC PEAT
SAND
Depth (ft bgs)
Arsenic (ppm)
0
200
400
600
800
1000


ESB-2006
FILL
White Material
MMC CLAY
MMC PEAT
SAND
Depth (ft bgs)
0
2
4
6
8
10
12
14
16
18
0
200
400
600
800
1000
1200
Arsenic (ppm)


ESB-2007
FILL
White Material
MMC Clay
SAND
Depth (ft bgs)
0
2
4
6
8
10
12
14
16
18
0
500
1000
1500
2000
2500
Arsenic (ppm)


ESB-2008
FILL
White Material
MMC CLAY
MMC PEAT
SAND
Depth (ft bgs)
0
2
4
6
8
10
12
14
16
18
0
500
1000
1500
2000
2500
Arsenic (ppm)


ESB-2009
FILL
White Material
MMC CLAY
MMC PEAT
SAND
Depth (ft bgs)
0
2
4
6
8
10
12
14
16
18
0
500
1000
1500
2000
2500
3000
Arsenic (ppm)

ATTACHMENT 4

Table of Sequential Extraction Procedure (SEP) results for individual clay (CL) and peat (PT) samples.

Sample ID	Fraction Number	Extractant	Fraction Description	As (mg/Kg)	Percentage in Fraction
ESB-2003-12-PT	**1**	0.05M $(NH_4)_2SO_4$	Non-specifically adsorbed arsenic	6.20	5%
ESB-2003-12-PT	**2**	0.05M $NH_4H_2PO_4$	Specifically-sorbed arsenic	54.8	44%
ESB-2003-12-PT	**3**	0.2M $(NH_4)C_2O_4$	Amorphous Fe and Al oxyhydroxides	41.1	33%
ESB-2003-12-PT	**4**	0.2M $(NH_4)_2C_2O_4$ + 0.1M Ascorbic acid	Crystalline Fe and Al oxyhydroxides	2.45	2%
ESB-2003-12-PT	**5**	HNO_3/H_2O_2	Residual	20.2	16%
ESB-2003-12-PT	**Sum of Fractions**	-	-	125	

Sample ID	Fraction Number	Extractant	Fraction Description	As (mg/Kg)	Percentage in Fraction
ESB-2003-10.5-CL	**1**	0.05M $(NH_4)_2SO_4$	Non-specifically adsorbed arsenic	3.59	3%
ESB-2003-10.5-CL	**2**	0.05M $NH_4H_2PO_4$	Specifically-sorbed arsenic	64.9	47%
ESB-2003-10.5-CL	**3**	0.2M $(NH_4)C_2O_4$	Amorphous Fe and Al oxyhydroxides	40.1	29%
ESB-2003-10.5-CL	**4**	0.2M $(NH_4)_2C_2O_4$ + 0.1M Ascorbic acid	Crystalline Fe and Al oxyhydroxides	3.20	2%
ESB-2003-10.5-CL	**5**	HNO_3/H_2O_2	Residual	26.9	19%
ESB-2003-10.5-CL	**Sum of Fractions**	-	-	139	

Sample ID	Fraction Number	Extractant	Fraction Description	As (mg/Kg)	Percentage in Fraction
ESB-2004-11.5-CL	**1**	0.05M $(NH_4)_2SO_4$	Non-specifically adsorbed arsenic	235	5%
ESB-2004-11.5-CL	**2**	0.05M $NH_4H_2PO_4$	Specifically-sorbed arsenic	1360	26%
ESB-2004-11.5-CL	**3**	0.2M $(NH_4)C_2O_4$	Amorphous Fe and Al oxyhydroxides	2900	56%
ESB-2004-11.5-CL	**4**	0.2M $(NH_4)_2C_2O_4$ + 0.1M Ascorbic acid	Crystalline Fe and Al oxyhydroxides	300	6%
ESB-2004-11.5-CL	**5**	HNO_3/H_2O_2	Residual	341	7%
ESB-2004-11.5-CL	**Sum of Fractions**	**-**	**-**	5140	

ESB-2004-13-PT	**1**	0.05M $(NH_4)_2SO_4$	Non-specifically adsorbed arsenic	6.68	7%
ESB-2004-13-PT	**2**	0.05M $NH_4H_2PO_4$	Specifically-sorbed arsenic	35.6	38%
ESB-2004-13-PT	**3**	0.2M $(NH_4)C_2O_4$	Amorphous Fe and Al oxyhydroxides	21.0	23%
ESB-2004-13-PT	**4**	0.2M $(NH_4)_2C_2O_4$ + 0.1M Ascorbic acid	Crystalline Fe and Al oxyhydroxides	3.48	4%
ESB-2004-13-PT	**5**	HNO_3/H_2O_2	Residual	25.8	28%
ESB-2004-13-PT	**Sum of Fractions**	**-**	**-**	92.6	

Sample ID	Fraction Number	Extractant	Fraction Description	As (mg/Kg)	Percentage in Fraction
ESB-2005-10-CL	**1**	0.05M $(NH_4)_2SO_4$	Non-specifically adsorbed arsenic	228	5%
ESB-2005-10-CL	**2**	0.05M $NH_4H_2PO_4$	Specifically-sorbed arsenic	340	7%
ESB-2005-10-CL	**3**	0.2M $(NH_4)C_2O_4$	Amorphous Fe and Al oxyhydroxides	2350	52%
ESB-2005-10-CL	**4**	0.2M $(NH_4)_2C_2O_4$ + 0.1M Ascorbic acid	Crystalline Fe and Al oxyhydroxides	1240	27%
ESB-2005-10-CL	**5**	HNO_3/H_2O_2	Residual	402	9%
ESB-2005-10-CL	**Sum of Fractions**	**-**	**-**	4560	

ESB-2005-14-PT	**1**	0.05M $(NH_4)_2SO_4$	Non-specifically adsorbed arsenic	1.20	8%
ESB-2005-14-PT	**2**	0.05M $NH_4H_2PO_4$	Specifically-sorbed arsenic	6.84	43%
ESB-2005-14-PT	**3**	0.2M $(NH_4)C_2O_4$	Amorphous Fe and Al oxyhydroxides	3.04	19%
ESB-2005-14-PT	**4**	0.2M $(NH_4)_2C_2O_4$ + 0.1M Ascorbic acid	Crystalline Fe and Al oxyhydroxides	0.72	5%
ESB-2005-14-PT	**5**	HNO_3/H_2O_2	Residual	3.95	25%
ESB-2005-14-PT	**Sum of Fractions**	**-**	**-**	15.8	

Sample ID	Fraction Number	Extractant	Fraction Description	As (mg/Kg)	Percentage in Fraction
ESB-2006-15-PT	**1**	0.05M $(NH_4)_2SO_4$	Non-specifically adsorbed arsenic	4.49	7%
ESB-2006-15-PT	**2**	0.05M $NH_4H_2PO_4$	Specifically-sorbed arsenic	33.8	52%
ESB-2006-15-PT	**3**	0.2M $(NH_4)C_2O_4$	Amorphous Fe and Al oxyhydroxides	18.2	28%
ESB-2006-15-PT	**4**	0.2M $(NH_4)_2C_2O_4$ + 0.1M Ascorbic acid	Crystalline Fe and Al oxyhydroxides	1.79	3%
ESB-2006-15-PT	**5**	HNO_3/H_2O_2	Residual	7.00	11%
ESB-2006-15-PT	**Sum of Fractions**	**-**	**-**	65.3	

ESB-2006-14-CL	**1**	0.05M $(NH_4)_2SO_4$	Non-specifically adsorbed arsenic	0.85	6%
ESB-2006-14-CL	**2**	0.05M $NH_4H_2PO_4$	Specifically-sorbed arsenic	5.99	45%
ESB-2006-14-CL	**3**	0.2M $(NH_4)C_2O_4$	Amorphous Fe and Al oxyhydroxides	3.75	28%
ESB-2006-14-CL	**4**	0.2M $(NH_4)_2C_2O_4$ + 0.1M Ascorbic acid	Crystalline Fe and Al oxyhydroxides	1.02	8%
ESB-2006-14-CL	**5**	HNO_3/H_2O_2	Residual	2.49	19%
ESB-2006-14-CL	**Sum of Fractions**	**-**	**-**	13.3	

Sample ID	Fraction Number	Extractant	Fraction Description	As (mg/Kg)	Percentage in Fraction
ESB-2001-8-CL	**1**	0.05M $(NH_4)_2SO_4$	Non-specifically adsorbed arsenic	261	4%
ESB-2001-8-CL	**2**	0.05M $NH_4H_2PO_4$	Specifically-sorbed arsenic	338	5%
ESB-2001-8-CL	**3**	0.2M $(NH_4)C_2O_4$	Amorphous Fe and Al oxyhydroxides	2530	35%
ESB-2001-8-CL	**4**	0.2M $(NH_4)_2C_2O_4$ + 0.1M Ascorbic acid	Crystalline Fe and Al oxyhydroxides	3640	50%
ESB-2001-8-CL	**5**	HNO_3/H_2O_2	Residual	513	7%
ESB-2001-8-CL	**Sum of Fractions**	**-**	**-**	7280	

ESB-2001-10-PT	**1**	0.05M $(NH_4)_2SO_4$	Non-specifically adsorbed arsenic	8.82	1%
ESB-2001-10-PT	**2**	0.05M $NH_4H_2PO_4$	Specifically-sorbed arsenic	250	38%
ESB-2001-10-PT	**3**	0.2M $(NH_4)C_2O_4$	Amorphous Fe and Al oxyhydroxides	284	43%
ESB-2001-10-PT	**4**	0.2M $(NH_4)_2C_2O_4$ + 0.1M Ascorbic acid	Crystalline Fe and Al oxyhydroxides	20.0	3%
ESB-2001-10-PT	**5**	HNO_3/H_2O_2	Residual	97.2	15%
ESB-2001-10-PT	**Sum of Fractions**	**-**	**-**	660	

Sample ID	Fraction Number	Extractant	Fraction Description	As (mg/Kg)	Percentage in Fraction
ESB-2002-9-CL	**1**	0.05M $(NH_4)_2SO_4$	Non-specifically adsorbed arsenic	270	5%
ESB-2002-9-CL	**2**	0.05M $NH_4H_2PO_4$	Specifically-sorbed arsenic	477	9%
ESB-2002-9-CL	**3**	0.2M $(NH_4)C_2O_4$	Amorphous Fe and Al oxyhydroxides	3200	59%
ESB-2002-9-CL	**4**	0.2M $(NH_4)_2C_2O_4$ + 0.1M Ascorbic acid	Crystalline Fe and Al oxyhydroxides	959	18%
ESB-2002-9-CL	**5**	HNO_3/H_2O_2	Residual	546	10%
ESB-2002-9-CL	**Sum of Fractions**	**-**	**-**	5450	

ESB-2002-12-PT	**1**	0.05M $(NH_4)_2SO_4$	Non-specifically adsorbed arsenic	14.4	7%
ESB-2002-12-PT	**2**	0.05M $NH_4H_2PO_4$	Specifically-sorbed arsenic	105	52%
ESB-2002-12-PT	**3**	0.2M $(NH_4)C_2O_4$	Amorphous Fe and Al oxyhydroxides	62.0	31%
ESB-2002-12-PT	**4**	0.2M $(NH_4)_2C_2O_4$ + 0.1M Ascorbic acid	Crystalline Fe and Al oxyhydroxides	3.96	2%
ESB-2002-12-PT	**5**	HNO_3/H_2O_2	Residual	18.2	9%
ESB-2002-12-PT	**Sum of Fractions**	**-**	**-**	203	

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Sample ID	Fraction Number	Extractant	Fraction Description	As (mg/Kg)	Percentage in Fraction
ESB-2007-15-CL	**1**	0.05M $(NH_4)_2SO_4$	Non-specifically adsorbed arsenic	1.24	1%
ESB-2007-15-CL	**2**	0.05M $NH_4H_2PO_4$	Specifically-sorbed arsenic	18.5	18%
ESB-2007-15-CL	**3**	0.2M $(NH_4)C_2O_4$	Amorphous Fe and Al oxyhydroxides	11.2	11%
ESB-2007-15-CL	**4**	0.2M $(NH_4)_2C_2O_4$ + 0.1M Ascorbic acid	Crystalline Fe and Al oxyhydroxides	2.01	2%
ESB-2007-15-CL	**5**	HNO_3/H_2O_2	Residual	71.5	69%
ESB-2007-15-CL	**Sum of Fractions**	-	-	104	

ESB-2008-16-PT	**1**	0.05M $(NH_4)_2SO_4$	Non-specifically adsorbed arsenic	0.85	10%
ESB-2008-16-PT	**2**	0.05M $NH_4H_2PO_4$	Specifically-sorbed arsenic	1.89	23%
ESB-2008-16-PT	**3**	0.2M $(NH_4)C_2O_4$	Amorphous Fe and Al oxyhydroxides	2.43	29%
ESB-2008-16-PT	**4**	0.2M $(NH_4)_2C_2O_4$ + 0.1M Ascorbic acid	Crystalline Fe and Al oxyhydroxides	0.49	6%
ESB-2008-16-PT	**5**	HNO_3/H_2O_2	Residual	3.52	42%
ESB-2008-16-PT	**Sum of Fractions**	-	-	8.32	

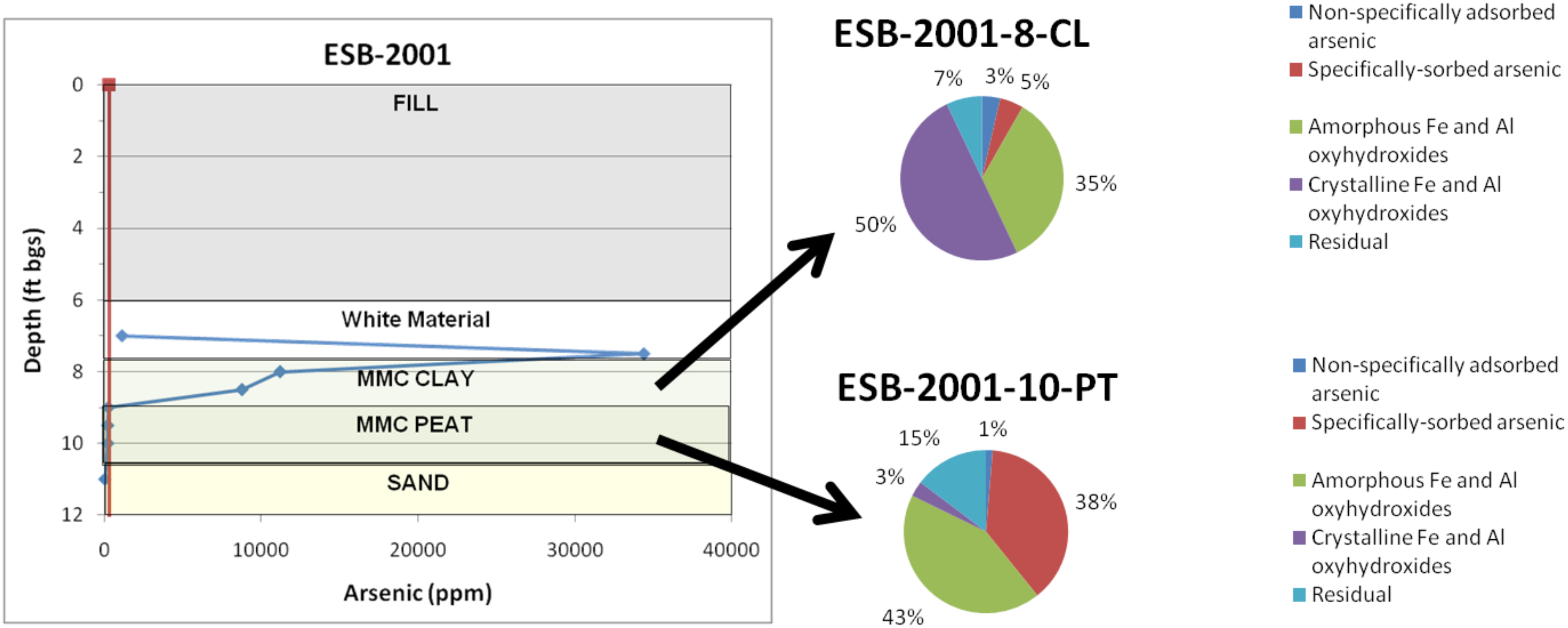
Sample ID	Fraction Number	Extractant	Fraction Description	As (mg/Kg)	Percentage in Fraction
ESB-2009-16-PT	**1**	0.05M $(NH_4)_2SO_4$	Non-specifically adsorbed arsenic	0.85	11%
ESB-2009-16-PT	**2**	0.05M $NH_4H_2PO_4$	Specifically-sorbed arsenic	2.02	27%
ESB-2009-16-PT	**3**	0.2M $(NH_4)C_2O_4$	Amorphous Fe and Al oxyhydroxides	1.93	26%
ESB-2009-16-PT	**4**	0.2M $(NH_4)_2C_2O_4$ + 0.1M Ascorbic acid	Crystalline Fe and Al oxyhydroxides	0.43	6%
ESB-2009-16-PT	**5**	HNO_3/H_2O_2	Residual	3.09	41%
ESB-2009-16-PT	**Sum of Fractions**	**-**	**-**	7.47	

ESB-2009-14-CL	**1**	0.05M $(NH_4)_2SO_4$	Non-specifically adsorbed arsenic	0.85	11%
ESB-2009-14-CL	**2**	0.05M $NH_4H_2PO_4$	Specifically-sorbed arsenic	2.43	32%
ESB-2009-14-CL	**3**	0.2M $(NH_4)C_2O_4$	Amorphous Fe and Al oxyhydroxides	1.68	22%
ESB-2009-14-CL	**4**	0.2M $(NH_4)_2C_2O_4$ + 0.1M Ascorbic acid	Crystalline Fe and Al oxyhydroxides	0.59	8%
ESB-2009-14-CL	**5**	HNO_3/H_2O_2	Residual	2.80	37%
ESB-2009-14-CL	**Sum of Fractions**	**-**	**-**	7.50	

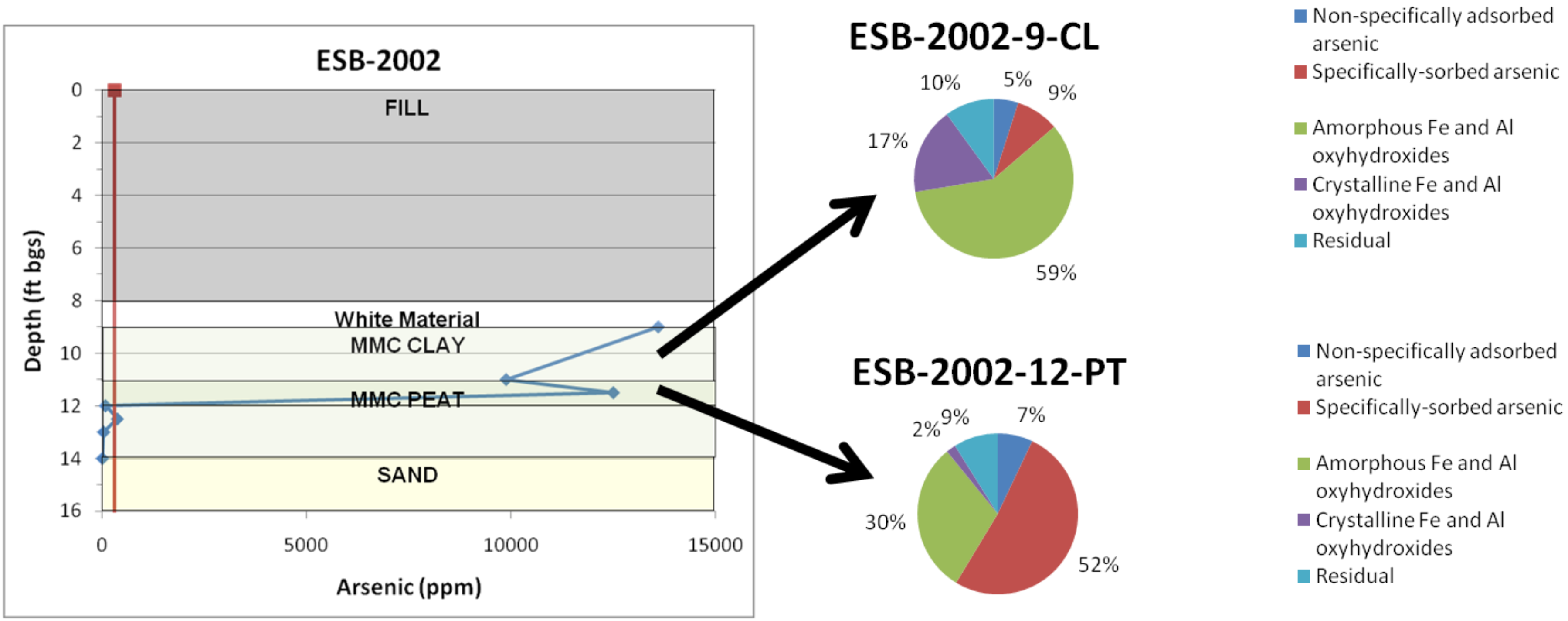
Sample ID	Fraction Number	Extractant	Fraction Description	As (mg/Kg)	Percentage in Fraction
ESB-2008-14-CL	**1**	0.05M $(NH_4)_2SO_4$	Non-specifically adsorbed arsenic	0.85	7%
ESB-2008-14-CL	**2**	0.05M $NH_4H_2PO_4$	Specifically-sorbed arsenic	4.95	40%
ESB-2008-14-CL	**3**	0.2M $(NH_4)C_2O_4$	Amorphous Fe and Al oxyhydroxides	4.00	32%
ESB-2008-14-CL	**4**	0.2M $(NH_4)_2C_2O_4$ + 0.1M Ascorbic acid	Crystalline Fe and Al oxyhydroxides	0.98	8%
ESB-2008-14-CL	**5**	HNO_3/H_2O_2	Residual	2.49	20%
ESB-2008-14-CL	**Sum of Fractions**	-	-	12.4	

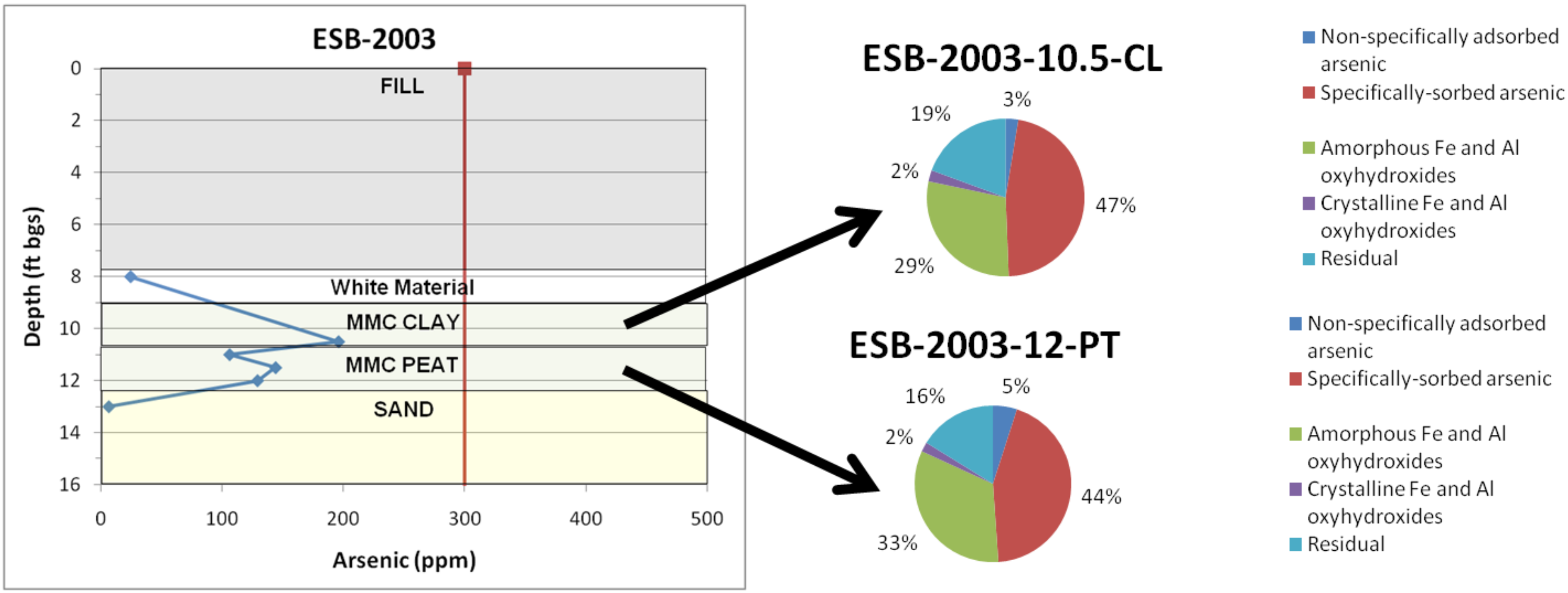
ESB-2008-14-CL MD	**1**	0.05M $(NH_4)_2SO_4$	Non-specifically adsorbed arsenic	0.85	11%
ESB-2008-14-CL MD	**2**	0.05M $NH_4H_2PO_4$	Specifically-sorbed arsenic	2.99	40%
ESB-2008-14-CL MD	**3**	0.2M $(NH_4)C_2O_4$	Amorphous Fe and Al oxyhydroxides	1.93	26%
ESB-2008-14-CL MD	**4**	0.2M $(NH_4)_2C_2O_4$ + 0.1M Ascorbic acid	Crystalline Fe and Al oxyhydroxides	0.58	8%
ESB-2008-14-CL MD	**5**	HNO_3/H_2O_2	Residual	1.98	26%
ESB-2008-14-CL MD	**Sum of Fractions**	-	-	7.48	

Graphical representations of the percentage of arsenic associated with each fraction (i.e., 1–5, corresponding with dark blue through light blue), based on results of the Sequential Extraction Procedure (SEP) for individual clay (CL) and peat (PT) samples. The Stratification Program results for each boring are shown for reference.

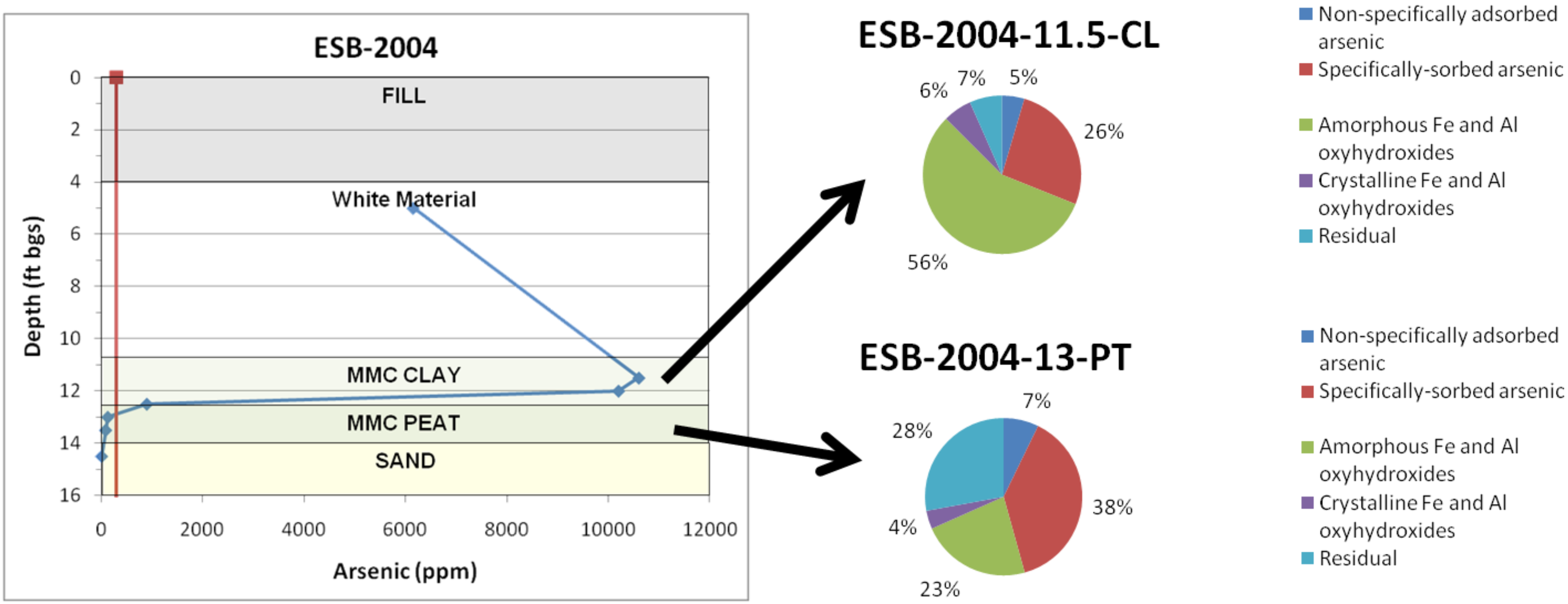


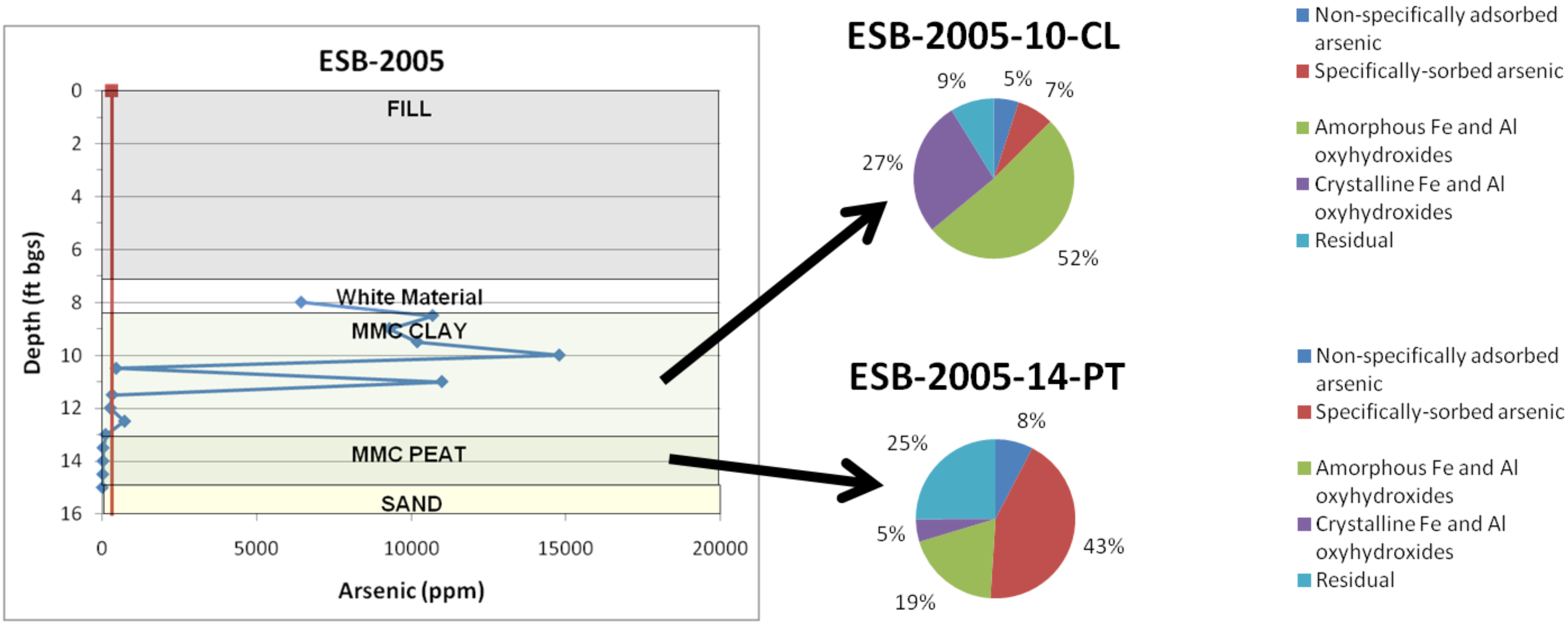
Golder Associates

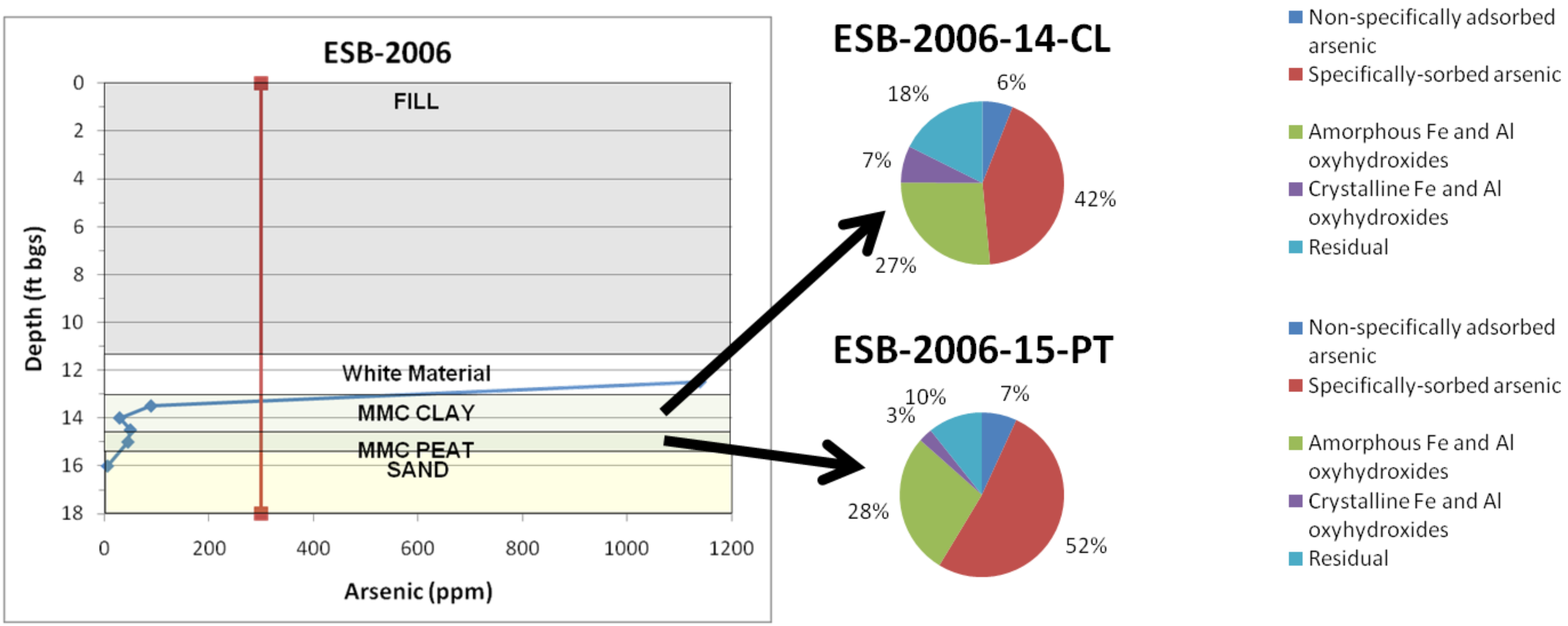

ESB-2002
FILL
White Material
MMC CLAY
MMC PEAT
SAND
Depth (ft bgs)
0
2
4
6
8
10
12
14
16
0
5000
10000
15000
Arsenic (ppm)
ESB-2002-9-CL
10%
5%
9%
17%
59%
ESB-2002-12-PT
2%
9%
7%
30%
52%
Non-specifically adsorbed arsenic
Specifically-sorbed arsenic
Amorphous Fe and Al oxyhydroxides
Crystalline Fe and Al oxyhydroxides
Residual

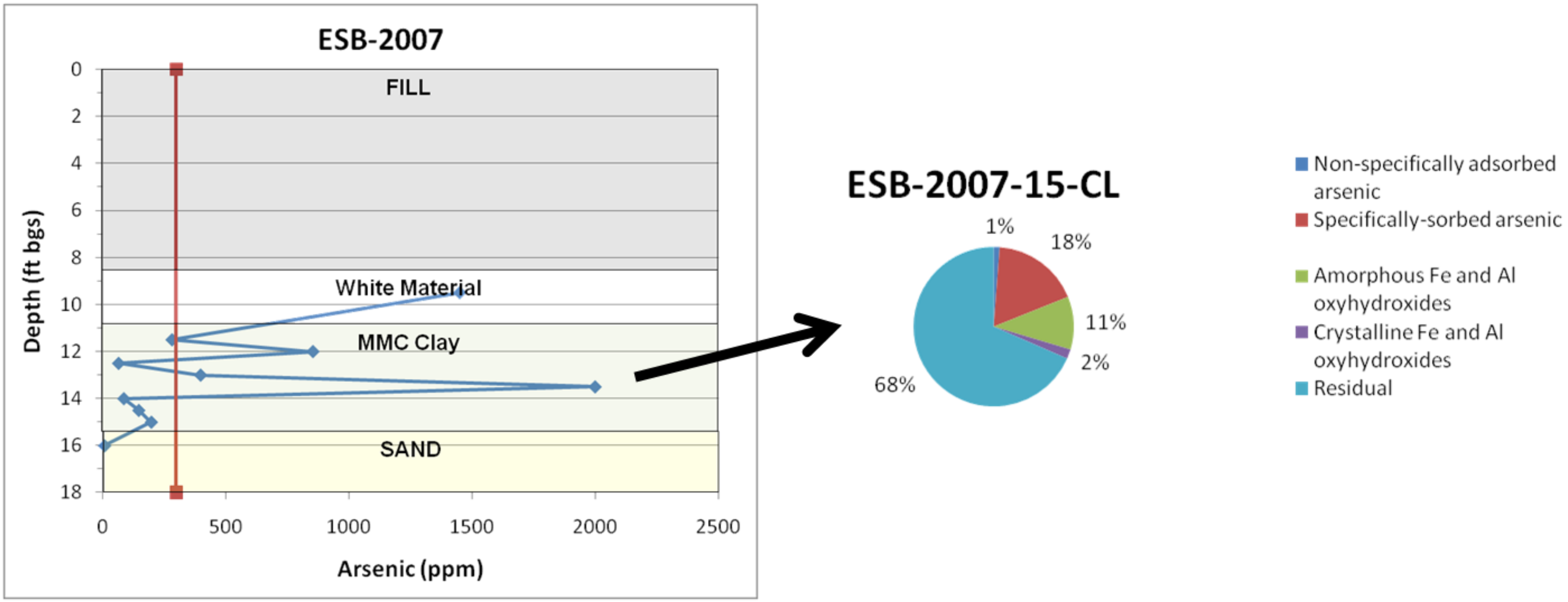

ESB-2003
FILL
White Material
MMC CLAY
MMC PEAT
SAND
Depth (ft bgs)
0
2
4
6
8
10
12
14
16
0
100
200
300
400
500
Arsenic (ppm)
ESB-2003-10.5-CL
3%
47%
29%
2%
19%
ESB-2003-12-PT
5%
44%
33%
2%
16%
Non-specifically adsorbed arsenic
Specifically-sorbed arsenic
Amorphous Fe and Al oxyhydroxides
Crystalline Fe and Al oxyhydroxides
Residual
Non-specifically adsorbed arsenic
Specifically-sorbed arsenic
Amorphous Fe and Al oxyhydroxides
Crystalline Fe and Al oxyhydroxides
Residual

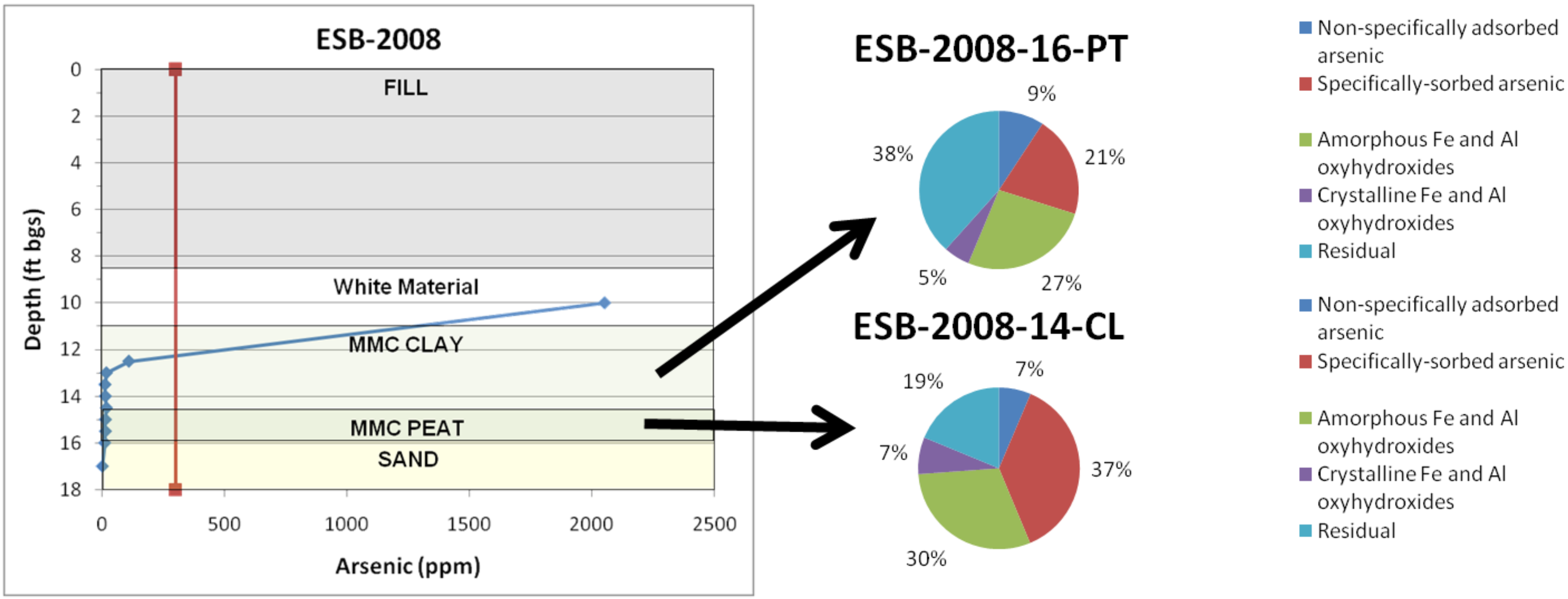
Attachment 4-13

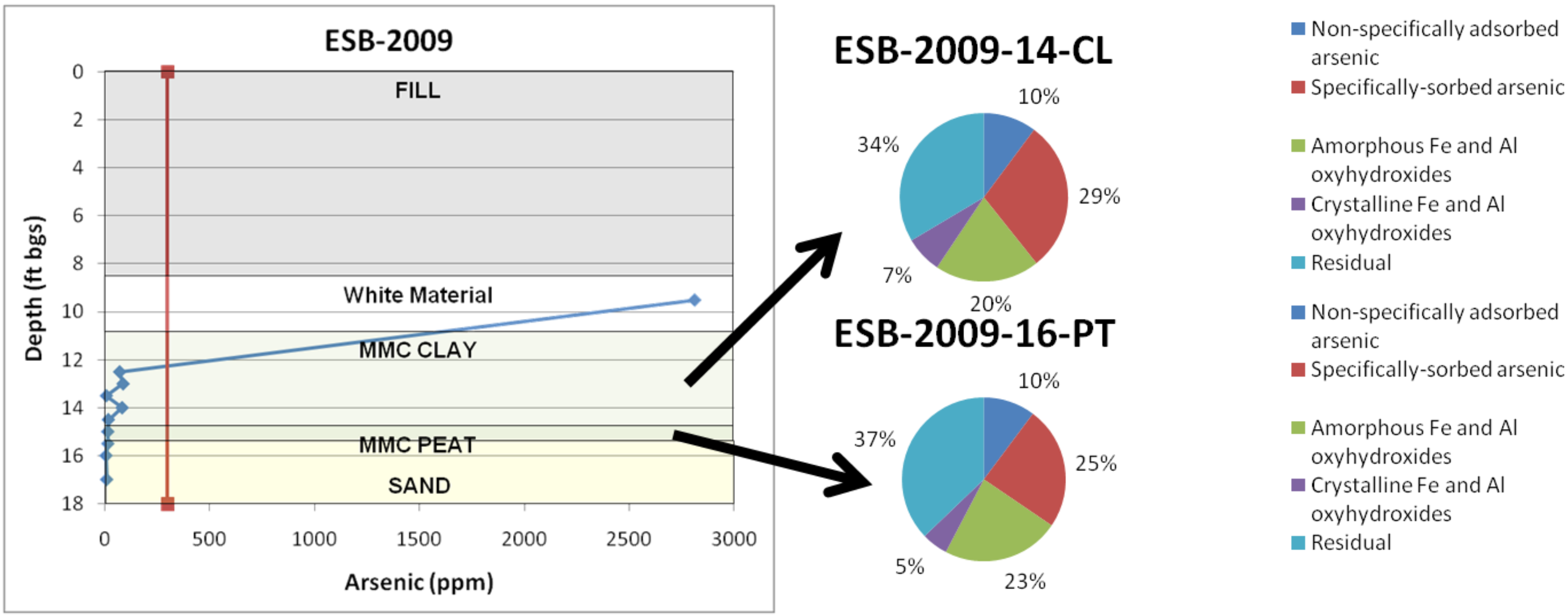



ESB-2005
FILL
White Material
MMC CLAY
MMC PEAT
SAND
Depth (ft bgs)
0
2
4
6
8
10
12
14
16
0
5000
10000
15000
20000
Arsenic (ppm)
ESB-2005-10-CL
9%
5%
7%
27%
52%
Non-specifically adsorbed arsenic
Specifically-sorbed arsenic
Amorphous Fe and Al oxyhydroxides
Crystalline Fe and Al oxyhydroxides
Residual
ESB-2005-14-PT
8%
25%
5%
43%
19%
Non-specifically adsorbed arsenic
Specifically-sorbed arsenic
Amorphous Fe and Al oxyhydroxides
Crystalline Fe and Al oxyhydroxides
Residual


ESB-2006
FILL
White Material
MMC CLAY
MMC PEAT
SAND
Depth (ft bgs)
0
2
4
6
8
10
12
14
16
18
0
200
400
600
800
1000
1200
Arsenic (ppm)
ESB-2006-14-CL
6%
42%
27%
7%
18%
ESB-2006-15-PT
7%
52%
28%
3%
10%
Non-specifically adsorbed arsenic
Specifically-sorbed arsenic
Amorphous Fe and Al oxyhydroxides
Crystalline Fe and Al oxyhydroxides
Residual

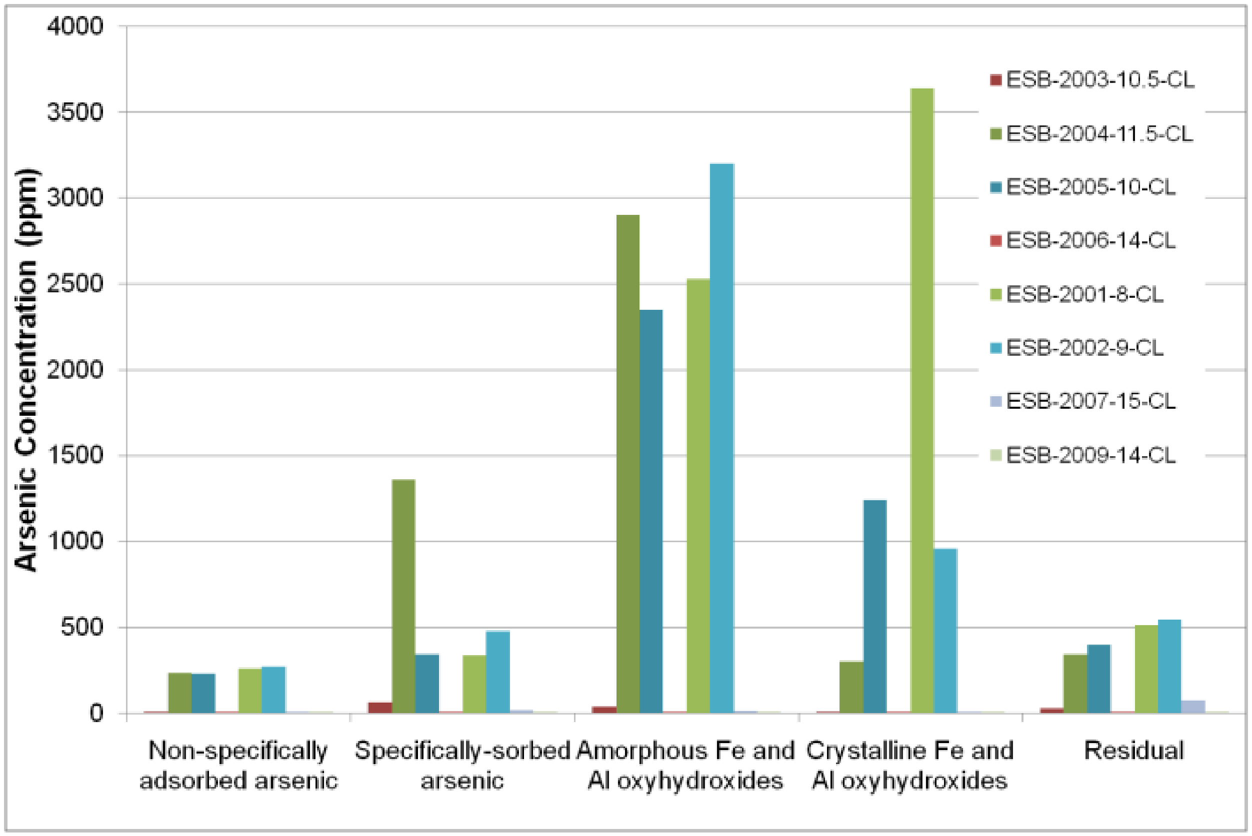

ESB-2007
FILL
White Material
MMC Clay
SAND
Depth (ft bgs)
0
2
4
6
8
10
12
14
16
18
0
500
1000
1500
2000
2500
Arsenic (ppm)
ESB-2007-15-CL
1%
18%
11%
2%
68%
Non-specifically adsorbed arsenic
Specifically-sorbed arsenic
Amorphous Fe and Al oxyhydroxides
Crystalline Fe and Al oxyhydroxides
Residual


ESB-2008
FILL
White Material
MMC CLAY
MMC PEAT
SAND
Depth (ft bgs)
0
2
4
6
8
10
12
14
16
18
0
500
1000
1500
2000
2500
Arsenic (ppm)
ESB-2008-16-PT
9%
21%
27%
5%
38%
ESB-2008-14-CL
7%
37%
30%
7%
19%
Non-specifically adsorbed arsenic
Specifically-sorbed arsenic
Amorphous Fe and Al oxyhydroxides
Crystalline Fe and Al oxyhydroxides
Residual

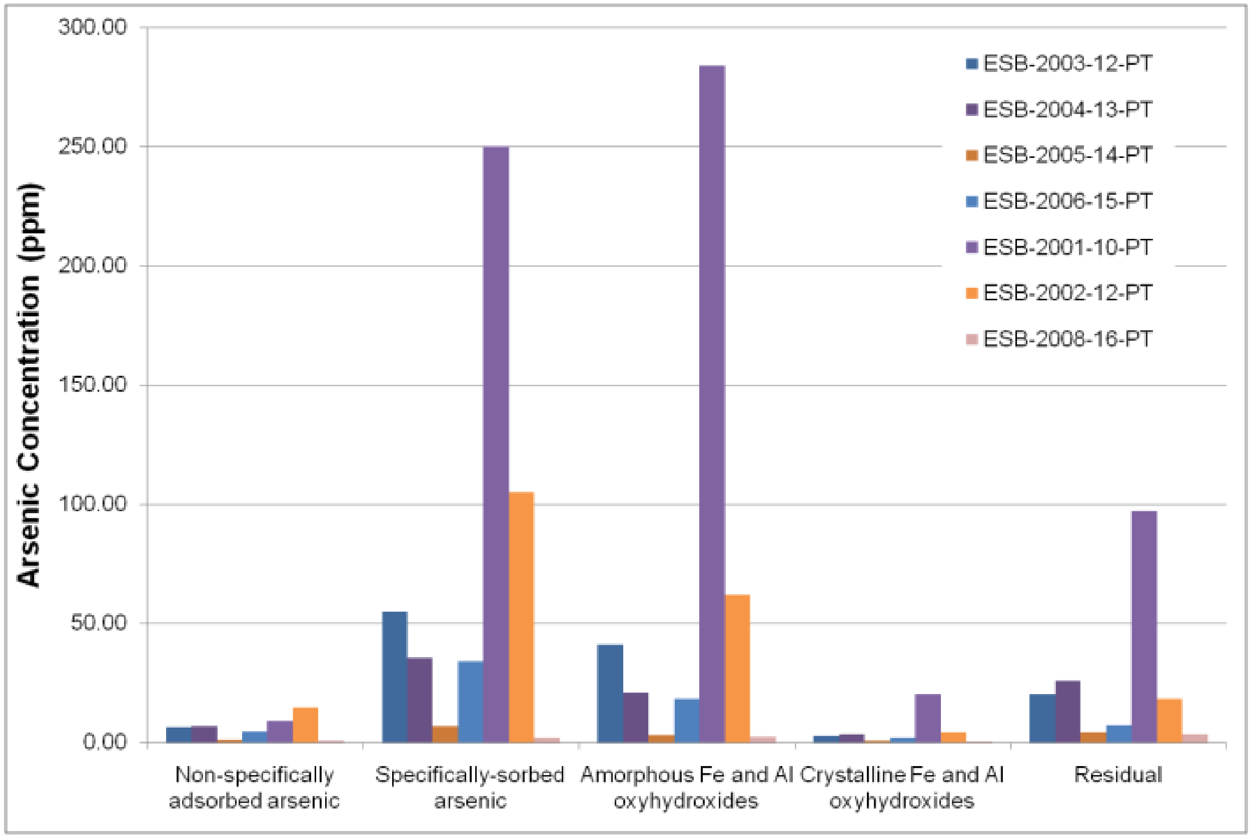

ESB-2009
Depth (ft bgs)
0
2
4
6
8
10
12
14
16
18
FILL
White Material
MMC CLAY
MMC PEAT
SAND
0
500
1000
1500
2000
2500
3000
Arsenic (ppm)
ESB-2009-14-CL
10%
29%
20%
7%
34%
ESB-2009-16-PT
10%
25%
23%
5%
37%
Non-specifically adsorbed arsenic
Specifically-sorbed arsenic
Amorphous Fe and Al oxyhydroxides
Crystalline Fe and Al oxyhydroxides
Residual
Non-specifically adsorbed arsenic
Specifically-sorbed arsenic
Amorphous Fe and Al oxyhydroxides
Crystalline Fe and Al oxyhydroxides
Residual

Summary graphs of the concentration (A–B) and percentage (C–D) of arsenic associated with each fraction, based on results of the Sequential Extraction Procedure (SEP) for all clay (CL) and peat (PT) samples.

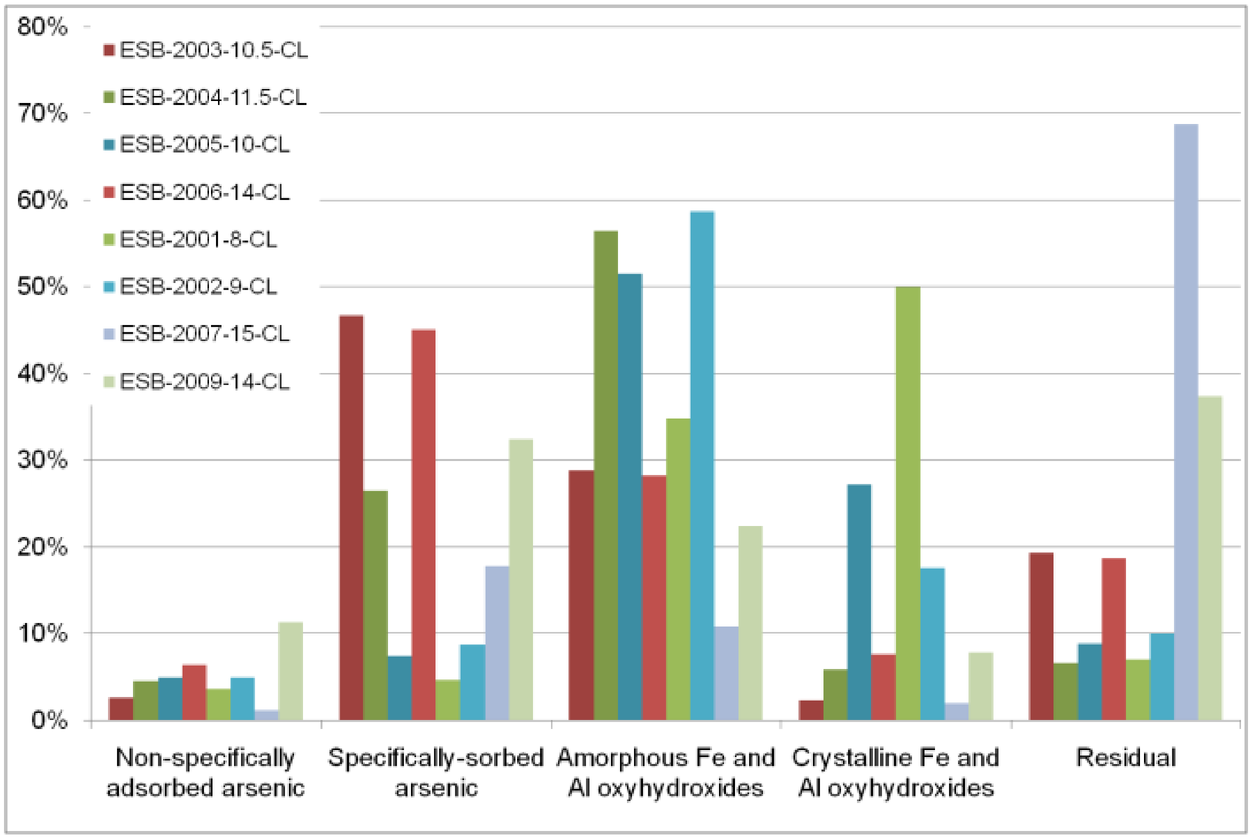
A



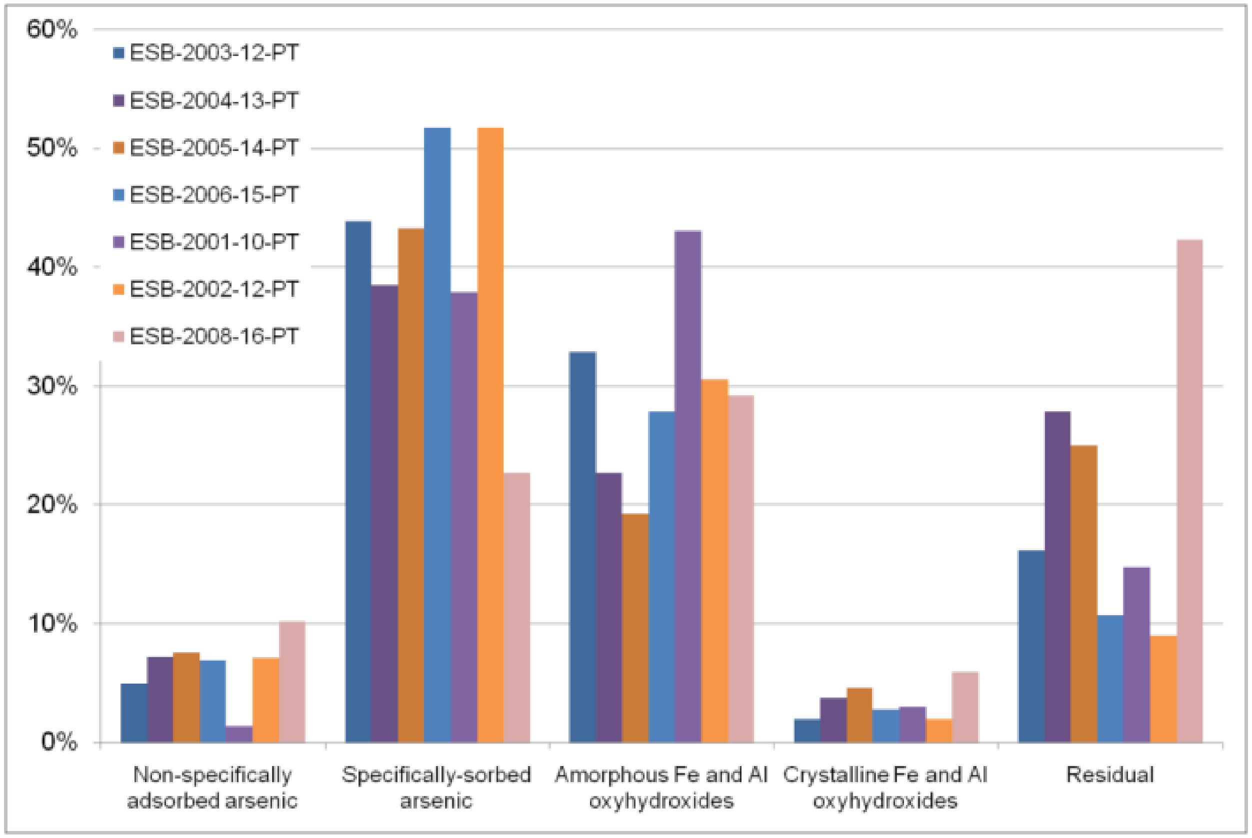
B


Arsenic Concentration (ppm)
300.00
250.00
200.00
150.00
100.00
50.00
0.00
ESB-2003-12-PT
ESB-2004-13-PT
ESB-2005-14-PT
ESB-2006-15-PT
ESB-2001-10-PT
ESB-2002-12-PT
ESB-2008-16-PT
Non-specifically adsorbed arsenic
Specifically-sorbed arsenic
Amorphous Fe and Al oxyhydroxides
Crystalline Fe and Al oxyhydroxides
Residual

C


80%
70%
60%
50%
40%
30%
20%
10%
0%
ESB-2003-10.5-CL
ESB-2004-11.5-CL
ESB-2005-10-CL
ESB-2006-14-CL
ESB-2001-8-CL
ESB-2002-9-CL
ESB-2007-15-CL
ESB-2009-14-CL
Non-specifically adsorbed arsenic
Specifically-sorbed arsenic
Amorphous Fe and Al oxyhydroxides
Crystalline Fe and Al oxyhydroxides
Residual

D


60%
50%
40%
30%
20%
10%
0%
ESB-2003-12-PT
ESB-2004-13-PT
ESB-2005-14-PT
ESB-2006-15-PT
ESB-2001-10-PT
ESB-2002-12-PT
ESB-2008-16-PT
Non-specifically adsorbed arsenic
Specifically-sorbed arsenic
Amorphous Fe and Al oxyhydroxides
Crystalline Fe and Al oxyhydroxides
Residual